Range Ecology of Mountain Caribou

(Rangifer tarandus caribou) in Jasper National Park, 1971-1974

by John G. Stelfox, Peter Kuchar and John A. Bindernagel

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RANGE ECOLOGY OF MOUNTAIN CARIBOU *(Rangifer tarandus caribou)* IN JASPER NATIONAL PARK, 1971-1974

by

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WLU 200 - Caribou

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March 15, 1978

Mr. W.C. Turnbull
Director, Western Region
Parks Canada, Calgary

Dear Sir:

Enclosed herewith, please find a report "Range Ecology of Mountain Caribou *(Rangifer tarandus caribou)* in Jasper National Park, 1971-1974", by John G. Stelfox, Peter Kuchar and John A. Bindernagel. This study was part of the CWS Parks Research function, jointly funded by Parks Canada and CWS.

The report presents the results of detailed range studies on subalpine, alpine-tundra and river delta caribou ranges and examines both habitat and plant species preferences of both caribou and elk. Monthly distributions of both species are correlated to snow depth, wind, elevation and exposure.

It also discusses population distributions of caribou in relation to forest types and summer snowfield distributions.

Checklists of plants found on caribou ranges are also provided.

There is a paucity of information on the range ecology of mountain caribou in Canada, thus we believe this report provides valuable baseline information on this subject.

Comments from Parks Canada on the content, conclusions and recommendations of the report are solicited.

Yours truly,

M.R. Robertson
Regional Director

ABSTRACT

The range ecology of caribou in Jasper National Park was studied during 1971-1974 in response to concern by the Warden Service that caribou numbers were declining while elk numbers increased. Caribou numbers fluctuated between 360 and 875 from 1915 to 1960, while elk numbers increased from none in 1915, to 88 in 1920 and 1900 in 1960. There had been a marked warming trend and the conversion of many mature spruce-fir forests into pine forests, grassland and scrub ranges since 1850 AD.

Five important caribou ranges above 1830 m and their corresponding dry weight plant biomasses (kg/ha) during this study were: Engelmann Spruce-Subalpine Fir (1188), Mountain Heather (1105), Fellfield Tundra (978), Alpine and Forest Tundra Meadow (478) and Boulder Rubble Field (no biomass data). One important low-elevation spring and early winter range was Delta Shoreline and Wet Grassland (637).

Ten plant species that contributed most to caribou summer diet were: *Rhacomitrium lanuginosum, Equisetum scirpoides, Pleurozium schreberi, Pedicularis arctica, Dryas integrifolia, Polytrichum piliferum, Betula glandulosa, Dryas octopetala, Senecio resedifolius* and *Peltigera apthosa*. Lichens and graminoids were the main winter-spring forage groups, with considerable use of dwarf shrubs and rock lichens. In late winter in coniferous forests, caribou utilized *Alectoria glabra* and *Cetraria pinastri* lichens moderately in addition to *Cladina arbuscula* and *Peltigera apthosa* heavily.

There was a dominance-avoidance relationship between elk and caribou, with elk taking the dominant role and displacing caribou on common ranges. Both species competed heavily for *Equisetum* spp.

and moderately for *Carex* and *Festuca* spp. on low-elevation ranges, and for *Carex, Festuca, Salix, Astragalus, Potentilla, Equisetum* and *Cladonia* species on high-elevation ranges.

Caribou distributions were correlated to spruce-fir forests and to alpine-tundra ranges with broad valleys, traversable passes, and a scattering of summer snowfields.

Five habitat types where 81.8% of the caribou were observed were Alpine-Tundra, Delta Shoreline and Wet Grassland, Barren Ridges, Snowfield, and Heather Krummholz. Four habitat types where 87.7% of the elk were seen were Man-made Grasslands, Pine, Mixed Coniferous and Natural Grasslands.

There were marked seasonal, and often monthly, shifts in caribou distributions in response to floral phenology, climate and snowpack conditions. The summer diet changed rapidly with major emphasis on herbaceous species producing new growth and in the early flowering stage. Snowfields appeared vital for relief from summer heat and insects.

ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

The Warden Service in Jasper National Park (hereafter referred to as Jasper) expressed concern in the late 1960's that mountain caribou *(Rangifer tarandus caribou*)* numbers were declining while the numbers of elk *(Cervus elaphus nelsoni*)* and hikers were increasing on alpine-tundra caribou ranges.

Use by hikers in the Tonquin Valley increased from 299 hiker-nights in 1965 to 4101 hiker-nights in 1972, a 1271% increase (Stelfox and Warden Service 1974). In July 1961, 186 caribou were counted in the Portal, Whistler and Verdant creeks and Astoria River region west of the Athabasca River and between the Miette and Whirlpool rivers. By the late 1960's there were only 50 - 75 caribou while elk numbers had increased from nil to 150 - 200 in that region.

Elk were apparently absent from the park from the late 1800's until their reintroduction in the 1920's (Stelfox 1964). After their reintroduction they spread throughout low-elevation grasslands in the eastern portion of the park until the late 1950's and especially the 1960's, when they spread westward and also moved upward onto subalpine and alpine-tundra grasslands.

From 1971 to 1973, the senior author and the Jasper Warden Service studied the seasonal abundance and distribution of caribou and elk in the park and reported their findings (Stelfox and Warden Service 1974). They reported the 1960-1973 caribou population to be 425 - 711 compared with 1975 - 2375 elk. They concluded that the summer ranges of these two species overlapped above the 2000 m elevation in the Blue-Deer-

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* After A.W.F. Banfield, "The Mammals of Canada", Univ. of Toronto Press, 1974.

Mowitch creeks area of the upper Snake Indian watershed; in the Chak Basin, Astoria River and Cavell Alplands between the Miette and Whirlpool rivers; along the upper Maligne River; and along the Poboktan and upper Brazeau drainages. Their winter ranges overlapped above the 1400 m elevation along Willow-Blue-Rock creeks and the Snake Indian River above Willow Creek; along the upper Athabasca and Sunwapta rivers and the lower Whirlpool River area, as well as the Medicine-Maligne lakes area. There was concern that in these areas of range overlap, behavioral and foraging conflicts might exist to the detriment of caribou. Caribou behavior in relation to humans, elk and wolf influences was studied by the authors in cooperation with the Warden Service during 1971-1974 and their results reported (Stelfox and Bindernagel 1978).

During the period 1971-1974 detailed range ecology studies were conducted by the authors assisted by summer students on subalpine and alpine-tundra caribou ranges along the Maligne Range from Shovel Pass to the Bald Hills and the Poboktan Pass area as well as the low-elevation Medicine Lake delta. Less detailed range studies were conducted on the Cavell Alplands, the burn above Grizzly Flats (Sunwapta River), Marmot Mountain, Tonquin Valley, and Maccarib and Blue creeks plus the coniferous forest east of Maligne Lake.

The major objective of this study was to determine plant species composition and their utilization by caribou and elk, for plant communities that were important ranges for both species. Habitat preferences and seasonal distributions of both ungulate species were also studied in relation to climate (especially snow depth) and to vegetational history.

2.0 THE STUDY AREA

2.1 Geology (Geomorphology)

Jasper Park lies within the East Slope of the Rockies. Geologically, it entails some Precambrian quartzites but mostly Paloezoic sedimentary rock, chiefly shales, sandstone, limestone and dolomite (Mackay 1952, Heusser 1956). The mountains exhibit structural bedding which is horizontal, tilted, and folded and faulted. The thrust sheets form ranges with generally steep eastern escarpments and gentle westerly slopes (Mackay 1952). The mountains are separated by valleys considerably lower in elevation and deepened by stream and ice erosion along zones of structural and lithological weakness (Heusser 1956).

Some of the highest mountains in the Canadian Rockies occur in the park, especially in the Main Ranges west of the Pyramid Fault. Perpetually snow-clad, they are the source of glaciers of various sizes. The Columbia Icefield at the southern end of the park is the largest area of glaciers in the Rockies.

The Athabasca River forms the principal drainage. It and other streams lie in U-shaped valleys produced by Pleistocene glaciers. Evidence of glaciation may be seen to about 2500 m.

2.2 Climate

Jasper has a modified continental climate of fairly cold winters and warm summers. Prevailing westerly winds provide a moderately maritime influence. The mean annual temperature at Jasper townsite (1058 m) is 2.5°C; mean January temperature is -14.5°C, and July mean is 15.2°C. Mean annual precipitation is 375 mm and rises with increasing

elevation. The bottoms of main valleys have longer snow-free periods, warmer summers, and less favorable water balances than those elsewhere in the mountains (Stringer 1973).

In summer, mean air temperature maxima are consistently higher at lower elevations though mean minima may be about the same throughout the subalpine and alpine zone. Winter temperatures seem lowest at mid-elevations. The amplitude of diurnal and annual temperatures is smaller at the higher elevations. This is because in daytime air at the tops of the mountains and high hills does not warm up as much as at lower elevations, and at night cold air drains off the hills, collecting in higher valleys and smaller frost pockets. The lowest minima are always reached at these sites, not in midalpine elevations (Hrapko 1970, Kuchar 1975). In summer, many more nights of freezing temperatures are encountered in air-drainage channels than in forest or in normal alpine tundra (Kuchar 1975).

There are local areas of substantial precipitation, e.g. the Mt. Edith Cavell area and the Columbia Icefields. An east-west precipitation gradient also exists, with the Main Ranges and Continental Divide probably receiving much more snow than eastern ranges. There is much botanical evidence for this general E-W trend, e.g. the prevalence of snow- or moisture-loving plants such as partridgefoot *(Luetkea pectinata)*, western redcedar *(Thuja plicata)*, and red mountain heather *(Phyllodoce empetriformis)* in ranges west of the Divide.

The proportion of precipitation falling as snow increases with elevation, and is about 70-75% snow in the subalpine zone. Snow depth increases with elevation - at timberline it may be double that at the lower edge of the subalpine zone. It also varies greatly with exposure

and aspect. Windspeeds at higher elevations are generally greater in winter than in summer (Judson 1965). This accentuates the winter contrast between exposed and sheltered slopes. Treeless hillsides exposed to prevailing winds may have very little or no snow, while lee sides of ridges and some alpine basins may accumulate so much that total meltout is not achieved every year.

Superposing snow accumulation patterns over aspects, we see that the slopes exposed to prevailing winds are the S and W aspects. The dry and warm (relatively high temp. maxima and minima) habitats support more herbaceous and shrubby vegetation while the moist, cooler E and N aspects support forest (Stelfox 1975). These open slopes are very important winter ranges, especially for bighorn sheep (Stelfox and Taber 1969.

2.3 Soils

There are no published descriptions of soils in Jasper. The summary below has incorporated the following sources: G.M. Coen (pers. comm.), Stringer (1969, 1973), Laidlow (1971), Kuchar (1972a, 1975), and Hettinger (1975).

Soils in the park represent 5 orders: Podzol, Brunisol, Regosol, Gleysol and Chernozem. The typical forest soils at low to middle elevations are Brunisols, grading upward into Podzols. Brunisols and Podzols are also the "mature" type of alpine soil, mainly under heaths. Alpine soils in Jasper as in other mountain areas typically have very shallow profiles, poorly developed horizons, weak to non-existent structure, low clay content, a high degree of soil instability largely due to frost action and limited diversity of types (Knapik et al. 1973).

Areas of impeded drainage, notably marshland and bog in valley bottoms but also numerous small areas all the way up to alpine, are characterized by Gleysols. Some of the small grasslands in the Athabasca Valley have Chernozems (prairie soil). Active loess deposition in this valley, especially toward the E end, creates physiological drought conditions through deposition of calcium.

Disturbance (especially fire) has in many parts of the park increased the incidence of Regosols. These soils, on unstable sites, lack sufficient profile development to qualify in any other order (Can. Dep. Agr. 1974).

There is a broad range in mechanical composition, pH, and nutrients in the park's soils. In general, available nitrogen is inadequate, phosphorus is somewhat so, and potassium is adequate.

2.4 Vegetation

2.4.1 Zonation

There are three major ecological zones in Jasper - montane, subalpine and alpine - each with its characteristic combination of climate, flora and fauna (La Roi et al. 1975). Summaries of other systems of altitudinal zonation are provided by Daubenmire (1943) and Löve (1970).

The montane zone is best developed in the Athabasca Valley and ascends tributary valleys to about 1400 m. It has the greatest variety of vegetation types. Dry sites support grassland, some lodgepole pine savanna and dry shrubland. Dry-mesic sites have Douglas-fir forest and some lodgepole pine. Mesic sites have white and black spruce (upland and bog types), poplar forest and some lodgepole pine stands. There are also marshes and complex community mosaics on alluvium.

The subalpine zone, at 1400-2000 m, covers the largest area of the park and has mostly coniferous forest dominated in the climax state by Engelmann spruce and alpine fir. When destroyed by fire, spruce-fir areas often generate a lodgepole pine stage which reverts back to the original climax in one generation. Stands at lower elevations and on dry sites take longer and there may even be self-perpetuating pine stands (Hnatiuk 1969). The prevalence of lodgepole pine in the park, especially at middle elevations, has prompted La Roi et al. (1975) to consider the lower part of the subalpine zone, at 1400-1700 m, a pine-belt.

In addition to forest the subalpine zone also has avalanche paths, grassy and rocky slopes, and numerous small meadows dominated by shrubs, forbs or graminoids.

Above timberline, continuous forest gives way gradually, or rather abruptly, to a tundra landscape of low (<0.5m) vegetation. Timberline is between 1900-2100 m on cool aspects and 2000-2200 m on warm aspects. As elsewhere through western North America (Daubenmire 1968), zones are relatively higher on the warmer aspects in Jasper, about 100 m higher on W versus E slopes. The amplitude of timberline is about 300-400 m, though mostly at 2000-2200 m. Cliffs and rock rubble may locally obscure the relationship of subalpine to alpine, or may depress timberline below its potential altitude. It may also be depressed in very exposed windy areas, e.g. Signal Mt. (Hrapko 1970). The treeless bottoms of high subalpine valleys that extend into the alpine zone may also make demarcation difficult. The change in species composition and cover may be so gradual that only arbitrary separations can be made between "alpine" and "subalpine" meadows.

Directly above timberline is a variably wide, discontinuous subzone in which forest and tundra elements intermingle ("forest-tundra zone"), viz. moderately low (5-10 m) conifer clumps dotted over a tundra matrix. It is included as part of the alpine zone because structurally, floristically and environmentally it has closer affinities with alpine than with subalpine.

The tree islands become more stunted with increasing elevation and increasing wind exposure, and at their limit form prostrate krummholz, to 2200 m in the N sector of the park and 2300 m (locally to 2450 m) in the S sector (Landals and Knapik 1972).

2.4.2 Flora

Jasper has over 600 vascular plant species in about 250 genera and 67 families. There are also an estimated 250 bryophytes and 200 lichens. There are no known endemics, and the vascular flora is relatively depauperate compared to many others of the temperate region (Major and Bamberg 1967). The species fall into four major phytogeographical groups:

1. Arctic-alpine. Includes many of the above-timberline species and represents, as elsewhere through the alpine zone in the Rockies, southward extensions of arctic vegetation. Examples: *Dryas octopetala, Salix arctica, Silene acaulis, Oxyria digyna.*
2. Cordilleran. Largest percentage, derived from the original Rocky Mountain flora predating Pleistocene glaciation. Examples: most of the conifers and willows, *Castilleja* spp., *Arnica* spp., *Phyllodoce* spp., *Menziesia ferruginea, Vaccinium scoparium.*

3. Boreal. Species of the Canadian taiga that have moved down the Cordillera and established themselves as regular and important components of the mountain forests. Examples: *Juniperus communis, Cornus canadensis, Linnaea borealis, Vaccinium vitis-idaea, Pyrola* spp., *Arctostaphylos uva-ursi, Ledum groenlandicum.*

4. Wide-ranging. Common across much of North America or Europe. Examples: *Equisetum arvense, Poa pratensis, Fragaria virginiana.* Also many exotic weeds, chiefly in man-disturbed sites in the Athabasca Valley.

Nomenclature and taxonomy follows Hitchcock and Cronquist (1973) for vascular plants, Crum et al. (1973) for mosses, Schuster (1966-72) for hepatics, and Hale and Culberson (1970) for lichens. Vascular plants not in Hitchcock and Cronquist are taken from Hulten (1968).

2.4.3 Habitat types

Fifteen major habitat types have been designated in the caribou-elk studies of Jasper and are described below. The first six of these are of major importance to Rocky Mountain caribou.

Delta Shoreline and Wet Grassland

This habitat type (HT) includes a fairly unnatural assemblage of plant communities whose unifying feature is habitat, viz. the relatively fresh alluvial deposits of deltas, streambanks, sand and gravel bars, etc. Heavily forested alluvial areas fall into one or other of the forest HT's.

The important riparian groups are:

1. Aquatic vegetation, consisting of mainly a sparse cover of *Chara* and *Myriophyllum* on shallow (0.5-2 m) pond bottoms and lake margins. It should not be confused with true marshland which is found only at the lowest elevations and is dominated by cattails, bulrushes, spike rushes, water horsetails, water sedge, or dense and fairly diverse assemblages of submergent and floating macrophytes.
2. Sedge meadow, which occurs as a narrow (1-2 m) discontinuous border around lakes and ponds, and as a covering for partly infilled basins. It is dominated by a rather thick (15-30%) cover of *Carex aquatilis, C. rostrata,* and/or *C. saxatilis,* sometimes *Deschampsia caespitosus*. It overlies either a bare mineral surface (lake edge) or an alga-covered mud basin. It grades into a muddy or boggy sedge meadow which has a larger variety of sedges and a thick layer of mosses, such as *Drepanocladus* in flooded sections, *Aulacomnium palustre, Tomenthypnum nitens, Bryum pseudotriquetrum* and sometimes *Sphagnum* spp. in waterlogged sections. The herb and shrub cover is generally sparse but may be fairly diverse consisting of *Juncus* spp., *Equisetum* spp., *Scirpus caespitosus,* grasses, and forbs.
3. Fresh alluvial deposits, are those being reworked on an annual or irregular basis, and having a sparse cover of primary colonizers, especially *Epilobium latifolium*. In slightly more stable situations, particularly on gravel, *Dryas drummondii* mats are often the first invaders (Heusser 1956) and may assume virtually complete cover. The

best development is usually seen on sections of alluvial fans that have had no flowing water for at least one or two decades. Associated is a sparse but even cover of *Hedysarum boreale*, some *Arctostaphylos rubra*, and a sparse cover of willows especially *Salix drummondiana*. The moss *Tortella tortuosa* and lichens *Cladonia coccifera* and *C. pocillum* form a thin but high-cover crust. In time, *Shepherdia canadensis* may form a prominent shrub layer and trees, especially spruce, invade as the first step toward forest development.

On fresh alluvial deposits there is much microhabitat heterogeneity, due to the mosaic of soil moisture conditions brought on by only slight changes in relief. Small waterholes often have dense algal growths. Wet gravel, sandflats and mudflats are colonized by rushes (*Juncus balticus, J. castaneus* and others), sedges, and sometimes mosses. Colonies of horsetails (*Equisetum variegatum* and *E. arvense*) may be dominant to the exclusion of other plants. This is the case for much of the Medicine Lake delta. Mesic sections may have a plant cover that closely approximates that of upland forest. Alluvial sections near timberline may have a sparse cover of mountain heathers and blueberries. Xeric or relatively unstable gravel sections have mostly *Dryas drummondii*.

Lodgepole Pine Forest

Hnatiuk (1969) studied lodgepole pine stands in Jasper and Banff parks. He classified them into three main classes and eight forest types which can be arranged in an ecological series, from cool, moist stands generally at higher elevations, to warm, dry low-altitude

stands. There are many exceptions however, due to the effects of aspect and local drainage conditions.

The moist series has large amounts of one or more of the following within specific stands: *Menziesia ferruginea*, *Alnus crispa*, *Vaccinium scoparium*, and feather mosses (*Hylocomium splendens* and *Pleurozium schreberi* in a continuous or near-solid carpet averaging 15 cm thick). The *Menziesia* type occurs at high elevations, generally above 1670 m, as a nearly continuous layer (1.5 m high) of the shrub, with some *Shepherdia canadensis* and *Rhododendron albiflorum*. The *Alnus* type is at 1220-1525 m. The feather mosses and *Vaccinium scoparium* types occur in a wide elevational range, though the latter is generally characteristic of highest-elevation forest (which is usually unburned and therefore belongs to the spruce-fir HT).

Mesophytic stands are dominated in the understory by *Shepherdia canadensis*, other shrubs and forbs, or grasses. The *Shepherdia* type, with a prominent though open layer of the shrub dominant, occurs at 1160-1280 m on terraces and beside rivers. The mesophytic pine type has a mixture of the dominants of the moist group, though none in high cover. Also present are some *Ledum groenlandicum* and *Vaccinium vitis-idaea*. Transitional to xerophytic stands is the *Elymus innovatus* type, with no shrub layer but a well developed herb layer dominated by the *Elymus*. There are also some *Linnaea borealis* and *Juniperus communis*.

Xerophytic stands occupy warm, dry, low valley bottoms and low benches. Most of the ground cover is supplied by *Arctostaphylos uva-ursi;* also present are *Linnaea borealis* and *Elymus innovatus*.

According to Hnatiuk (1969), of all eight types the last two are probably the most utilized by large herbivores, especially elk.

There is little evidence of ungulate use in the moist high-elevation stands.

Many stands exhibit a simple overstory structure of even-aged pine trees. These are the original colonizers after intense fires killed all above-ground elements of former forest (La Roi et al. 1975). Some stands have two or more age classes, representing two different fires. A third group of stands entails fine-scale mosaics of two or more age classes. There are also remnant stands of senescent old lodgepole pine, with trees to 298 years old recorded by La Roi et al. (1975).

Studying forest stands in the Athabasca Valley in the area of Jasper townsite, La Roi et al. (1975) found by far the greatest number of pines to be 80-88 years old with a fair number 60-79 years old, reflecting the extensive burns in 1886-1890 and frequent burns to 1914.

Spruce-Fir

Beil (1966) concluded that Jasper's spruce-fir forests are structurally and floristically simple. The top and bottom layers, trees and bryoids, are best developed; the herb-dwarf shrub layer is less well developed; and the shrub layer is poorly developed. Only locally is there a thick shrub layer formed by *Menziesia ferruginea* and *Vaccinium membranaceum*. Other important underlying vascular plants are: *Salix* spp., *Linnaea borealis*, *Vaccinium scoparium*, *V. vitis-idaea*, *Empetrum nigrum*, *Cornus canadensis*, and *Pyrola secunda*. Forest sections, in cool basins or on slopes with seepage, may have muskeg-like vegetation, with a thick moss layer and *Ledum groenlandicum*, and possibly black spruce. As one travels upslope, mountain heathers gradually gain in importance, until near timberline they form the dominant groundcover.

Pleurozium schreberi and *Hylocomium splendens* form 60% of the ground bryoid layer. Together with *Dicranum scoparium, Ptilium crista-castrensis, Barbilophozia hatcheri* and *Peltigera aphthosa* they account for 94% of this layer. The epiphytic lichen layer is much better developed than in lodgepole pine forest. Black *Alectoria* species are most common; but the pale yellow *Usnea* species are equally luxuriant in some stands. There are many other species of bryoids but they are less conspicuous foliose and crustose forms.

Spruce *(Picea engelmannii)* is generally the taller emergent tree species with greater crown cover than fir *(Abies lasiocarpa)* which, with its tendency for layering, typically behaves as a tall shrub and small tree. With increasing elevation and snowcover, especially on cool moist exposures, fir is increasingly more important in the tree layer and also makes up most of the shrub layer. Pure stands are restricted to near timberline sites (Landals and Knapik 1972). Whitebark pine *(Pinus albicaulis)*, a timberline species through its Canadian Rockies range, is rare and local, occurring as stunted trees and gnarled shrubs on exposed rocky ridges. Only rarely does it extend into the middle subalpine zone.

Heather-Krummholz

This HT is by far the most complex of all types in its environmental relationships, numbers of plant communities, their variable structures and high species richness. There are four distinct groups of vegetation types and habitats.

1. Heath-dominated communities make up the bulk (80-90% of area) of this HT. They are best developed on the E side of mountains, also on N-facing slopes and locally on W-facing

slopes. The slopes are generally 5-25°, exceptionally to 35°, with well drained yet not excessively dry, cold soils that are relatively well developed (Orthic Brunisols). They are dominated by dwarf heaths in a high, even cover (20-40% true cover, often nearly 100% "canopy cover").

Most larger tracts of heath tundra entail a mosaic of two community types, one dominated by *Cassiope tetragona* and *Dryas octopetala* on slight rises and ridges, and lightly snow-covered in winter (rarely 1 m, usually 30-70 cm); the other by *Phyllodoce glanduliflora* and *Cassiope mertensiana* in the depressed sections is normally covered by at least 2 m of snow by late winter (Kuchar 1975). The second type covers by far the most area. Toward timberline *Vaccinium scoparium* is also important, and *Phyllodoce empetriformis* may be conspicuous. There is a sparse (5-10%) cover of herbs and other shrubs, chiefly *Artemisia norvegica, Antennaria lanata, Salix arctica, S. nivalis, Lycopodium alpinum, Carex spectabilis. Luetkea pectinata* is locally abundant in deepest-snow sites. There is a relatively large variety of bryophytes (especially Dicranaceae) which covers 10-40% from most xeric to dampest communities; and of lichens (especially fruticose forms and the crustose species *Lepraria neglecta)* which covers 5-25% from dampest to most xeric communities.

2. Herb meadows cover about 5-10% of the Heather-Krummholz HT (more in areas of higher precipitation e.g. the Mt. Edith Cavell area). They are typically small but have a thick mantle of forbs, graminoids and usually mosses. The

covers of each separate species when added together often exceed 100%. They are normally covered by 1-2 m of snow and melt out in early June. Unifying features of the HT are: discharge of water (and probably nutrients) through the community from upslope snowbanks; soils therefore are more silty or clayey than other alpine types; absence of frost action and high herb cover and productivity. Important species are *Artemisia norvegica, Anemone occidentalis, Senecio triangularis, Arnica mollis, Trollius laxus, Pedicularis bracteosa, Potentilla diversifolia, Valeriana sitchensis, Erigeron perigrinus, Luzula parviflora, Carex spectabilis,* other graminoids, *Antennaria lanata, Veronica wormskjoldii* and a number of other smaller herbs. Some plants may be present in low cover but are conspicuous when in flower, e.g. *Castilleja rhexifolia, Senecio pauciflorus, Aquilegia flavescens.* The dwarf shrub *Salix arctica* is also usually abundant (5-15% cover) and there is usually a thick layer of mosses dominated by *Aulacomnium palustre.*

There are also sites intermediate between heath and herb meadow, dominated jointly by a dense herb layer and heath layer in a very high total cover.

3. Snowbed meadows are dominated mostly by *Carex nigricans* and other graminoids, comprise 5% of the HT.
4. Dense or open-centered tree "islands" are mainly fir, up to 10+ m in diameter. Total cover in the Heather-Krummholz areas is only 5-10%. There is also krummholz, but as it becomes increasingly stunted, implying greater wind exposure;

the habitat supports vegetation more typical of upland alpine tundra.

There are also willow-dominated shrub meadows in some low alpine valleys and local damp sites. They are treated as part of the Shrubland HT.

Alpine-Tundra

The Alpine-Tundra HT consists of the following communities:

1. Upland communities, which are fairly dry but stable and generally well vegetated. They range in elevation from 2135-2590 m. These communities have a variable appearance and occur on ridges and slopes of all aspects. They exist in the form of vegetation stripes, or discrete mat-islands, or on rocky slopes, or as fields of solifluction terracettes. They are thinly snow-covered (rarely over 1 m) and melt out by early to mid-May. They are dominated by a very variable cover (2-25% live cover, 5-100% mat cover) of mat-forming shrubs especially *Dryas octopetala (= D. hookeriana)* on acidic rock and *D. integrifolia* on base-rich substrata. Also present is a variable, often low cover of *Salix arctica, Empetrum nigrum, Salix nivalis,* and *Vaccinium vitis-idaea.* Other vascular species, rarely adding up to 5% cover, include a variety of herbs and graminoids expecially *Antennaria alpina, Astragalus alpinus, Myosotis sylvatica, Oxytropis podocarpa, O. campestris, Pedicularis arctica, Solidago multiradiata, Luzula spicata, Hierochloe alpina, Festuca brachyphylla, Poa grayana, Saxifraga bronchialis* and *S. oppositifolia.* Bryophytes, especially *Rhacomitrium lanuginosum, Polytrichum*

piliferum and *Hypnum revolutum*, are restricted to or are more abundant in damper microsites. Lichens, abundant (generally 20-40% cover) in all parts of the community, exceed all other plant groups in total cover, except in mesic sites where moss cover may be near-continuous. Saxicolous species, especially in the genera *Alectoria*, *Cetraria*, *Hypogymnia*, *Umbilicaria*, *Lecanora*, *Rhizocarpon*, are on the more exposed, gravelly, vascular-free portions. Fruticose species, especially in the genera *Alectoria*, *Cladonia*, *Cladina*, *Dactylina*, *Cetraria*, *Stereocaulon* and *Thamnolia*, predominate in depressed sections and in association with shrub mats.

2. Upland communities on stony soils in relatively windswept sites with very thin winter snowcover. These often occur on warm aspects and consist of a sparse to dense cover of graminoids expecially *Carex nardina*, *C. rupestris*, *Kobresia bellardii*, sometimes *Agropyron latiglume* or other grasses.
3. Isolated heath communities. These occur above the general Heather-Krummholz band and occur up to 2560 m.
4. Cliff ledges, mostly on E aspects. W-facing cliff ledges are often too dry to support vegetation. These communities contain a relatively rich flora with most species coming from upland tundra and forb meadows. A few, e.g. *Artemisia michauxiana* and *Arnica rydbergii*, are characteristic of ledges and cliff bases.
5. Boggy sites, generally very small and local, are located in sites of impeded drainage, with a gleysol soil. They have a layer of *Eriophorum* spp. and *Carex* spp. over mosses (*Calliergon*, *Drepanocladus*, sometimes *Sphagnum*).

6. Snowbed communities are small, in concavities, on the lee sides of ridges and on other sites with deep snow accumulation and late meltout. The growing season is usually shorter than two months. *Carex nigricans* is the outstanding dominant, forming a dense sward. Associated is a thin cover of *Deschampsia atropurpurea* and other grasses. *Antennaria lanata* usually forms a 1-2 m wide band between the snowbed community and heath tundra.

   There are also very late-melting snowbeds with a loose pebble surface and sparse (about 5%) cover of graminoids, chiefly *Luzula* spp., also *Carex pyrenaica, Poa cusickii,* a few herbs e.g. *Cardamine bellidifolia.* There may also be a sparse moss cover, chiefly *Polytrichastrum,* but no lichens.

Barren Ridgetop and Slope

This habitat occurs on the most exposed, sometimes rather unstable sites, generally above 2290 m, on ridge crests, some slopes and "balds". It has a coarse surface with various-sized pebbles, sometimes boulders, and virtually no soil development (Regosol). This is a windy, xeric habitat with a low vascular plant cover, usually 5% and often 1%, with appressed forms: *Silene acaulis, Potentilla nivea, P. uniflora, Arenaria obtusiloba* and other cushion and rosette species. It also contains graminoids, e.g. *Carex phaeocephala, Poa* spp., *Luzula spicata* and other small plants e.g. *Campanula lasiocarpa, Cerastium beeringianum, Taraxacum lyratum, Crepis nana, Salix nivalis.* The moss cover is usually very low, while the lichen cover is very low to high (40%).

This type also includes lichen tundra: vascular plant cover nil, lichen cover usually 10%. Present are mainly crustose and appressed

fruticose and foliose forms, with high diversity especially on larger, more stable boulders. Bryophytes, especially *Rhacomitrium lanuginosum*, are important in crevices and on flat sheltered rocks.

With increasing plant cover, the Barren Ridgetop HT grades into the Alpine Tundra HT.

Shrubland

The Shrubland HT, well developed in high subalpine valleys, entails communities dominated by 0.5-2 m tall shrubs, chiefly willows (especially *Salix barrattiana*) and *Betula glandulosa*. There is a sparse to well-developed layer of forbs and graminoids beneath the shrub layer, and usually a thick layer of bryophytes.

Man-made Grassland

This HT occurs mostly along roadsides, particularly highway right-of-ways. Exotic grasses predominate, especially crested wheatgrass *(Agropyron cristatum)*, spike redtop *(Agrostis exarata)*, red fescue *(Festuca rubra)*, and Kentucky bluegrass *(Poa pratensis)*. With the grasses there are mixtures of exotic and native herbs such as strawberry *(Fragaria virginiana)*, clover *(Melilotus, Trifolium)*, etc.

Natural Grassland

Grassland covers portions of the valley bottoms, and also occurs on some exposed SW slopes of 25-37° (Stelfox 1975). Much of the grassland and scrub have been created by fires in the last 100 years (Flook 1964). Stringer (1973) described three grassland community types in Jasper park:

1. *Koeleria-Calamagrostis montanensis* grassland. On valley bottoms, these characteristically have low species diversity and low total cover of vascular plants. There are only 5 dominants: *Calamagrostis montanensis, Koeleria cristata, Antennaria nitida/microphylla, Artemisia frigida,*

and *Astragalus adsurgens*. Constant species include *Agropyron dasystachyum, Bromus inermis, Erigeron caespitosus, Linum perenne, Senecio streptanthofolius,* and *Solidago decumbens*. There are scattered small shrubs, mainly *Rosa woodsii* and *Potentilla fruticosa*. Terricolous lichens are very characteristic of the drier sites.

2. *Stipa richardsonii* shrub savanna. Includes many small isolated areas within subalpine and montane forests, 1375-1650 m, generally on S-facing 0-5° slopes. Dominants include *Agropyron dasystachyum, Bromus inermis, Danthonia intermedia, Stipa richardsonii, Poa pratensis, Arctostaphylos uva-ursi, Fragaria virginiana, Penstemon confertus, Potentilla fruticosa, Salix glauca*. The striking feature is the prominent shrub stratum.

3. *Elymus innovatus* shrub savanna. Isolated grassy areas on fairly steep S-facing slopes in the subalpine zone. Dominants include *Elymus innovatus, Amelanchier alnifolia, Arctostaphylos uva-ursi, Fragaria virginiana, Galium boreale, Rosa acicularis, Rubus idaeus*.

Mixed Coniferous Forest

This type generally consists of fire-successional stands of white spruce, black spruce, lodgepole pine, and/or Douglas-fir in the montane zone. It has a variable understory, usually fairly rich in plant cover and species. It probably also includes mature Douglas-fir stands on basal slopes and ridges in valley bottoms (Stringer 1966).

Poplar Forest

This type consists of small deciduous forest stands of aspen or balsam poplar on alluvial fans in the montane zone. Rich shrub and herb layers are present along with a very poor bryoid layer (Lulman 1976).

Deciduous-Coniferous

This HT consists of mixtures of poplars and conifers. The understory is intermediate.

Recent Burns

Very recent burns have fire mosses (e.g. *Ceratodon purpureus)*

and fireweed *(Epilobium angustifolium)* while slightly later stages have willows *(Salix* spp.) and other shrubs together with various forbs.

Avalanche Paths

Snow avalanching areas mainly on N or E aspects, maintain potential forest in a perpetually dwarfed state. The vegetation is characterized by a thick growth of shrubby alpine fir, often with abundant dwarf birch, Labrador tea and crowberry. Avalanche paths are rare on warm aspects, and here the vegetation resembles that of higher-elevation grasslands *(Arctostaphylos uva-ursi, Juniperus communis, Potentilla fruticosa,* grasses).

Snowfields

These are regions of permanent or temporary snow cover used by caribou primarily for escape from heat and insect harassment.

3.0 METHODS

3.1 Range

Range studies were conducted on 11 areas, namely:

Maligne Range

1. Evelyn Creek
2. Snowbowl (Jeffery Cr.)
3. Bald Hills
4. Maligne Pass
5. Maligne Lake
6. Medicine Lake Delta

Whirlpool-Miette

1. Tonquin Valley
2. Maccarib Creek
3. Marmot Basin

North Jasper

1. Blue Lake

South Jasper

1. Brazeau

For each major plant community the following range information was obtained:

1. Plant community description - Each community type was classified according to Kuchar (1972a) and then delineated on airphotos. The relative area occupied by each type was calculated by weighing portions of paper representing the area of each type. The total area was calculated with the aid of a planimeter. Information collected included community type, location, exposure, elevation, slope, physiognomy (% cover, height and dominant species in each vegetation stratum), topography and drainage, evidence of animal activity and community disturbance, age and successional status, a detailed map of the area sampled showing plot locations, and general comments on relevant observations.
2. Plant density, canopy coverage, utilization and phenology - This information was recorded for each plant species from 100 rectangular plots (10 x 40 cm = 400 cm^2) that were distributed throughout the community in the following manner. A restricted-randomized method was employed using two 100 m straight-line transects that radiated from the centre of the stand in a random manner, with the direction determined using the sweep-second hand of a watch. Along each line were 10 potential lateral positions, one every 10 m, yielding a total of 20 possible laterals. Ten positions were chosen randomly using numbered slips of paper. The direction of the selected plot from the lateral line (left or right) was also randomly selected using the sweep second-hand of a watch.

Cover (%) of each plant species was recorded according to 10 cover classes: 1 (< 0.25%), 2 (0.25-0.50%), 3 (0.50-1.00%), 4 (1-5%), 5 (5-15%), 6 (15-25%), 7 (25-50%), 8 (50-75%), 9 (75-95%), 10 (95-100%).

Utilization of plant species was recorded according to the percentage of the above-ground, non-woody biomass consumed: nil (0%), light (1-10%), moderate (11-50%) and heavy (> 50%).

Point-intercept transects (Shaw and Stiteler 1962) were used to obtain density, cover and utilization data at the Medicine Lake delta, at Marble Mtn. (Brazeau) and at Maligne Pass.

3. Plant biomass - Forbs, mosses and lichens,and graminoids in each of four randomly selected 1 m^2 plots (circular) were separated and weighed. Samples of each forage type were collected and weighed when green and again when air-dried to obtain correction factors for converting green to dry weights for each plot. From these weights the vegetation biomass per hectare was calculated. Where arboreal lichens were present, a 200 pace (1 pace ≈ 1 m) transect was randomly chosen (2100 m transects along the lines previously chosen for cover). All arboreal lichens within reach (≤ 2 m) on the nearest tree or shrub every 20 m along each transect were collected and weighed.
4. Tree and shrub density and coverage - These data were obtained for treed communities from 100 plots spaced 20 m apart.
5. Soil profile descriptions and topography - Soils were described according to mineral horizons and layers, texture, drainage,

organic matter, parent material and consistency. Landform topography descriptions were also recorded.

3.2 Ungulate Abundance

The Pellet Group Count method (Bennett et al. 1940) was used to obtain indirect enumeration data on the degree of use by caribou and other ungulates of various habitat types and plant communities. Pellet counts were made along restricted randomized transects 2.0 m wide and of varying lengths in order to stay within the perimeter of each habitat type or plant community. Pellet group densities per hectare (ha) were converted to ungulate days-use/ha using the defecation rate of 13.0 pellet-groups/day, which approximates the average rates reported for wild deer and elk in North America (Smith 1964, Neff et al. 1965). No defecation rates for caribou could be found in the literature.

The number of caribou fecal groups/ha is directly related to the length of time caribou spent in that plant community. A comparison of fecal group densities or animal days-use per hectare in each plant community is therefore a measure of the relative preference of caribou for each plant community.

Pellet groups were classified as either winter (dry, firm, well-shaped and non-adhering pellets) or summer (misshapen or amorphous groups) to differentiate the seasonal use of each area sampled.

3.3 Caribou Diet

The diet of caribou for the period May-October was determined from plant fragment identification of 193 fecal samples according to the technique described by Flinders and Hansen (1972). Dr. R. Hansen,

Range Science Department, Colorado State University and his staff conducted the microscopic analysis.

Caribou diet data were also obtained during range and caribou behavior studies. Diet preference index for each forage species was calculated by dividing % utilization by % canopy coverage. The degree of use on each species was calculated using the following utilization classes: nil (0%), light (1-10%), moderate (11-50%), and heavy (> 50%).

During winter, a rough estimate of caribou diet was obtained by carefully removing the snow from within and adjacent to feeding craters and then subjectively recording the relative abundance of plant species and the degree of utilization of each.

4.0 RESULTS AND DISCUSSION

4.1 Range

4.1.1 Vegetational history: 1800-1970

The vegetational history of Jasper and other mountain parks is intimately tied in with two factors - climatic change and activity of white man. Climatic change is inferred from evidence of glacial advances and recessions; activity of white man is generally most evident from fires.

Between 1350 and 1650 AD there was a major glacial advance, i.e. cooling period, in the Canadian Rockies (Heusser 1956). It reached its maximum in the Jasper area in the early 18th century and remained stationary until recession began in the last quarter of the 18th century. In the early 19th century there was a readvance followed by a general retreat beginning in the mid-1800's. There is abundant meteorological, oceanographic and glaciological evidence through western North America for a period of warmer drier climate beginning

in mid-late 19th century and escalating in the 1920-50 period (Longley 1954, Heusser 1956, Meier 1965, Franklin et al. 1971). The 1930-40 period was especially warm and dry, as evidenced by massive invasion of conifers into alpine meadows in the Coast Ranges (Franklin et al. 1971).

Coincident with the general warming trend of 1850 has been the increasing activity of white man in the mountains. The warming trend predisposed the landscape to fires and more xerophytic vegetation, so when white man entered the scene in the 19th century he started many forest fires which created extensive forests of lodgepole pine together with patches of grassland and scrub. Fire damage was especially severe in the 1860-1900 period, mainly due to promiscuous burning by whites (Wellner 1970).

In terms of Rocky Mountain caribou populations, the climatic and human history had a number of direct and indirect effects, all deleterious.

1. The production of lodgepole pine stands meant the destruction of much caribou habitat, i.e. mature spruce-fir forest. To be sure, since the retreat of Pleistocene glaciers there had always been large numbers of lodgepole pine in the mountains (Hansen 1949, Heusser 1956), but its abundance as reflected in palynological data increased greatly in the last 100 years.
2. The fire-origin grassland and scrub increased the grazing and browsing ranges of the four major ungulates - elk, bighorn sheep, mule deer, and moose (Flook 1964). Over-population and general spread of these, especially elk, has resulted in encroachment onto traditional caribou range.

3. There are direct conflicts between the shy caribou and man, as the latter becomes increasingly active on caribou range.
4. Not only have glaciers been shrinking, but the numbers and size of summer snowfields and snow patches is doubtless much lower than it was 50-100 years ago. Caribou do not lose heat very effectively and therefore may need to rely on summer snow patches for thermoregulation.

4.1.2 Community composition, species density and utilization

4.1.2.1 Composition, biomass and soil, Evelyn Creek

Five communities at the headwaters of Evelyn Creek above 1829 m were in a 5.3 km^2 study area during the period 2-15 August 1973. Using the classification of Kuchar (1972a), five plant communities or ecosystems were delineated, namely:

Engelmann Spruce - Subalpine Fir - Comprised 42% of the area (Stand #6);

Fellfield Tundra - comprised 25% of the area (Stand #4);

Mountain Heather - comprised 27% of the area (Stand #1);

Boulder Rubble Field - Comprised 3% of the area (Stand #2);

Alpine and Forest Tundra Meadows - comprised 3% of the area (Stands #3 and #5).

Two stands were studied in the Alpine and Forest Tundra Meadows community because of their importance to caribou and other ungulates as revealed by numerous pellet groups, tracks and animal sightings.

Results from each community are presented in Appendix II.

Vegetation biomass was greatest (1188 kg/ha) in the Engelmann Spruce-Subalpine Fir community, followed in sequence by Mountain Heather (1105 kg/ha), Fellfield Tundra (978 kg/ha) and Alpine and

Forest Tundra Meadow (478 kg/ha). This compares with 637 kg/ha for the Delta Shoreline and Wet Grassland community at Medicine Lake. Biomass compositions for each of the four communities at the headwaters of Evelyn Creek and the Medicine Lake delta community are presented in Table 1. Additional species to those found on the plots and shown in Tables 1-6 of Appendix II are shown in Table 7 of Appendix II.

Table 1. Vegetative biomass of five plant communities on caribou ranges.

COMMUNITY	DRY WEIGHT BIOMASS (kg/ha)				
	Forbs	Graminoids	Mosses & Lichens	Arboreal Lichens	Total
	EVELYN CREEK HEADWATERS				
Mountain Heather	1105	tr	tr	0	1105
Alpine & Forest Tundra Meadow	133	332	13	0	478
Fellfield Tundra	410	tr	568	0	978
Engelmann Spruce-Subalpine Fir	553	tr	634	0.5	1188
	MEDICINE LAKE DELTA				
Delta Shoreline & Wet Grassland	534*	103	0	0	637

* *Equisetum* spp.

4.1.2.2 Species density and utilization

The abundance and utilization of plant species on caribou ranges were determined on 18 occasions during the period 1971-1973 (Tables 2, 3, 4). Species and/or genera identified on these ranges

Table 4. Abundance/caribou utilization[1] of trees, shrubs, grasses, grass-like plants, horsetails and club-mosses at various sites in Jasper National Park, 1971-1973.

Species	Alpine Tundra 7000' - 7500'				Alpine Tundra 7500'- 8500'	Sub-alpine - Alpine Tundra 6500' - 7500'						Canadian Coniferous Zone 4500' - 6000'								
												Valley Bottom 4700' - 6000'						East Slope 6000'	Average Abundance (% cover)	Average Utilization (%)
	Marmot Basin (January 1972)	Marmot Basin (August 1972)	Campus Pass (August 1972)	Mt. Clitheroe (August 1972)	Brazeau (John-John Creek) (August 1972)	Bald Hills[2] (May 1972)	Bald Hills (1972-1973)	Snowbowl (October 1971)	Snowbowl (July 1972)	Evelyn Creek (July 1972)	Maligne Pass (July 1972)	Snake Indian (Blue Lake) (July 1972)	Sunwapta Falls (June 1972)	Buck Lake (June 1972)	Maligne Lake (March 1972)	Medicine Lake (May 1972, 1973)	Medicine Lake (January 1973)	"Old Burn" (Grizzly Flats) (June 1973)		
TREES AND SHRUBS																				
Abies lasiocarpa		M/N			U/M	S-A/N-H		M/L	S/N										4.0	17.8
Betula sp.					+													M/M	5.0	38.0
Betula glandulosa					U/M							M/L	+						5.0	13.0
Menziesia glabella					+	M/L	+			S/N				+	M/L	+		S/N	2.8	6.5
Juniperus communis					+									+					U	U
Juniperus horizontalis					+										+	+	+	S-A/N	3.3	4.3
Juniperus scopulorum																			U	U
Picea engelmannii	M/L-M				U/N	+	+	S/N	S/N	M/N					+	+	+	S-A/N	3.3	4.3
Pinus albicaulis	S/N				+						+								0.5	0.0
Pinus contorta	M/N				+	+	+								+	+	+	S/N	2.8	0.0
Pinus flexilis	S/N				+														0.5	0.0
Rosa acicularis															M/M				5.0	38.0
Salix sp.					+					S/N	+		+					S/M	0.5	19.0
Salix arctica	M/U	S-M/N	M/L		M-A/N						M/L								5.1	6.5
Salix barrattiana					+				M/N			+						+	5.0	0.0
Salix glauca					M-A/N														7.5	0.0
Salix nivalis		S/N			M-A/N	+		M/M				M/L							3.4	12.3
Salix vestita					+														U	U
Shepherdia canadensis															S/L				0.5	13.0
GRASSES AND GRASS-LIKE PLANTS																				
Agropyron latiglume					+														U	U
Agropyron trachycaulum													+						U	U
Agrostis stolonifera																+			U	U
Agrostis variabilis					+														U	U
Bromus inermis					+														U	U
Bromus marginatus								S/L											0.5	13.0
Bromus pumpellianus					+														U	U
Calamagrostis montanensis								S/L											0.5	13.0
Calamagrostis purpurascens					+														U	U
Carex sp.				S/N	M-A/N	U/M			A/N	S/N	+		+	+		S/N		+	3.8	13.0
Carex albo-nigra						S-M/N-L	U/N												2.8	44.5
Carex concinna															M/M				5.0	38.0
Carex nardina					+	+	+												U	U
Carex nigricans					+						M/N								5.0	0.0
Carex raymondii					+														U	U
Carex scirpoidea					+			A/L				M/M							7.5	25.5
Carex spectabilis					+						+	A/L[3]							10.0	13.0
Danthonia intermedia					+														U	U
Deschampsia caespitosa					+										S/L				0.5	13.0
Elymus innovatus					S/U														0.5	U
Festuca sp.	M/N				S/N														2.8	0.0
Festuca brachyphylla					+	S-M/N-L													2.8	6.5
Festuca ovina								U/L											U	13.0
Kobresia bellardii					+														U	U
Phleum alpinum					M/U			S/L											2.8	6.5
Poa sp.				+	+														U	U
Poa alpina (pattersonii?)[4]					M/U														5.0	U
Poa arctica					+	+					+								U	U
Poa cusickii					+[3]						+								U	U
Poa rupicola					+														U	U
Scirpus caespitosus												A/N							10.0	0.0
Trisetum spicatum					M/N	S-M/N-L													3.9	3.3
Unidentified	M/L	S/N	S/N		S/N										A/M	A/M	+	M/M	4.5	23.6
HORSETAILS AND CLUB-MOSSES																				
Equisetum sp.				M/L	M/N														5.0	6.5
Equisetum arvense													+						U	U
Equisetum scirpoides													+		M/M	A/N			7.5	57.0
Equisetum variegatum					+						+								U	U
Lycopodium sp.														+[3]		+		M/N[3]	5.0	0.0
Lycopodium alpinum	S/N																		0.5	0.0
Lycopodium annotinum									S/N										0.5	0.0
Lycopodium selago												+							U	U

[1] Explanation of symbols used:

+ - present, but unclassified
U - unclassified abundance or utilization

Abundance (in terms of ground cover):

S - scarce ≤ 1% coverage
M - moderately common 2-8% coverage
A - abundant 9+% coverage

Utilization:

N - not used
L - lightly used 1-25%
M - moderately used 26-50%
H - heavily used 51-100%

[2] Data compiled from eight sample sites in the Bald Hills, May 1972.

[3] Uncertain identification.

Table 3. Abundance/caribou utilization of forbs at various sites in Jasper National Park, 1971-1973.
(For an explanation of the symbols used see Table 2.)

Species	Alpine Tundra 7000' - 7500'				Alpine Tundra 7500'-8500'	Sub-alpine - Alpine Tundra 6500' - 7500'						Canadian Coniferous Zone 4500' - 6000'							Average Abundance (% cover)	Average Utilization (%)
												Valley Bottom 4700' - 6000'						East Slope 6000'		
	Marmot Basin (January 1972)	Marmot Basin (August 1972)	Campus Pass (August 1972)	Mt. Clitheroe (August 1972)	Brazeau (John-John Creek) (August 1972)	Bald Hills (May 1972)	Bald Hills (1972-1973)	Snowbowl (October 1971)	Snowbowl (July 1972)	Evelyn Creek (July 1972)	Maligne Pass (July 1972)	Snake Indian (Blue Lake) (July 1972)	Sunwapta Falls (June 1972)	Buck Lake (June 1972)	Maligne Lake (March 1972)	Medicine Lake (May 1972,1973)	Medicine Lake (January 1973)	"Old Burn" (Grizzly Flats) (June 1973)		
FORBS AND LOW SHRUBS																				
Achillea millefolium					+										S/N				0.5	0.0
Allium schoenoprasum					+														U	U
Anemone sp.		S/N	S/L	M/N	S/N														3.3	3.3
Anemone occidentalis					M/N				M/N	S/N	M/N	M/N							5.1	0.0
Anemone parviflora												+							U	U
Antennaria sp.					S-M/N														2.8	0.0
Antennaria alpina					+														U	U
Antennaria lanata			S/N	M/N	+				M/N	S/N	M/N								3.5	0.0
Antennaria pulcherrima*												M/N							U	U
Arctostaphylos uva-ursi					+								+						2.8	19.0
Arenaria obtusiloba					+								+		M/M	+		S/N	U	U
Arnica sp.			S/L	S/L	+														0.5	13.0
Arnica gracilis*													+						U	U
Arnica mollius*											+								U	U
Artemisia norvegica					+						+								U	U
Aster sibiricus					+														U	U
Astragalus alpinus					+						+								U	U
Caltha leptosepala			M/M	M/L	M/N				S/N		M/H	M/L							4.3	23.3
Campanula sp.					S/N														0.5	0.0
Cassiope sp.		M/N	M/N	S/N	M/N														3.9	0.0
Cassiope mertensiana	A/N				+						M/N	A/M							8.3	12.7
Cassiope tetragona					+	M/N-H	+		A/N	S/L		A/M						+	6.4	22.3
Castilleja sp.				S/L															0.5	13.0
Castilleja rhexifolia											+								U	U
Cerastium beeringianum					+														U	U
Claytonia lanceolata									M/N			S/N							2.8	0.0
Cornus canadensis							+									+		S/N	0.5	0.0
Crepis nana					+														U	U
Draba aurea					+														U	U
Draba lanceolata					+														U	U
Dryas sp.	M/L	M/N			M-A/N					S/L									5.6	6.5
Dryas drummondii													+						U	U
Dryas hookeriana						+	+												U	U
Dryas integrifolia	A/M																		10.0	38.0
Dryas octopetala						M-A/M-H		M/L											6.3	35.0
Dryas octopetala* (? = hookeriana)												A/N							10.0	0.0
Empetrum nigrum		S/N				S-M/N-M	+			M/L	*							A/N	4.6	8.0
Epilobium sp.										S/U									0.5	U
Epilobium alpinum					+														U	U
Epilobium latifolium											+								U	U
Erigeron aureus					M/N						+								5.0	0.0
Fragaria virginiana							+												0.5	0.0
Gentiana sp.					S/N								+		S/N				0.5	0.0
Gentiana glauca						+													U	U
Gentianella sp.* (? = Gentiana prostrata)	+	S/N																	0.5	0.0
Gentianella crinata					+														U	U
Heuchera sp.								S/M											0.5	38.0
Juncus sp.				+	M/N														5.0	0.0
Juncus drummondii											+								U	U
Juncus nodosus					+														U	U
Kalmia polifolia					M/N				M/N		S/N								3.5	0.0
Ledum groenlandicum							+		S/N			+							3.5	12.7
Linnaea borealis														+	M/M	+	+	M/N	5.0	38.0
Lomatium sp.*	M/M													+	M/M	+	*		5.0	38.0
Luetkea pectinata											A/N								10.0	0.0
Luzula sp.				+							M/N								5.0	0.0
Luzula parviflora					+														U	U
Mycosotis alpestris					+														U	U
Oxyria digyna					+						+								U	U
Oxytropis podocarpa					+														U	U
Parnassia palustris			+																U	U
Pedicularis sp.				S/L	M/N				M/N		+								U	U
Pedicularis arctica											M/H							+	3.5	4.3
Pedicularis bracteosa								M/M			+								5.0	76.0
Pedicularis groenlandica					+							S/N							2.8	19.0
Petasites sp.				+	M/N						M/N		+					+	U	U
Phacelia sericea					+														5.0	0.0
Phyllodoce sp.	A/U			M/N		+	+	A/N	A/N		+	A/M		+				+	U	U
Phyllodoce empetriformis	S/N				A/U													S/N	8.8	0.0
Phylloduce glandulifolia		S/N	S/N		+					A/H									5.3	12.7
Polemonium viscosum					+														3.7	25.3
Polygonum sp.					A/N														U	U
Polygonum vivparum					+														10.0	0.0
Potentilla sp.					S/N														U	U
Potentilla concinna					+														0.5	0.0
Potentilla diversifolia					+														U	U
Potentilla fruticosa					+														U	U
Potentilla nivea					M/N	U/H													U	U
Pyrola sp.							+												5.0	38.0
Pyrola asarifolia																		+	U	U
Pyrola secunda																+			U	U
Ranunculus sp.					A/N													+	U	U
Ranunculus eschscholtzii											S/N								10.0	0.0
Ribes sp.																			0.5	0.0
Saussurea densa					+								+					+	U	U
Saxifraga sp.			M/N	M/N	S/U						+								U	U
Saxifraga bronchialis		S/N			+	S/M													3.5	0.0
Sedum stenopetalum					S/U														0.5	19.0
Selaginella sp.			S/N	S/N															0.5	U
Selaginella dense										M/N									0.5	0.0
Senecio sp.								S/M			+		+*					+*	5.0	38.0
Senecio resedifolius*					M/U														0.5	38.0
Senecio triangularis			+	+	A/U						S/N								5.0	U
Sibbaldia procumbens					+														5.3	0.0
Silene acaulis	+	S/N				S-M/L													U	U
Solidago sp.					M/N						M/L								1.6	3.3
Solidago multiradiata					+														5.0	6.5
Townsendia sp.			S/U	S/N	+										S/L				0.5	13.0
Trifolium repens																			0.5	0.0
Trollius albiflorus			M/M	M/M	+				M/N		S/N		+						U	U
Vaccinium scoparium					S/U				S/N	S/L	+	+	+	+		+	+	+*	3.9	19.0
Vaccinium uliginosum							+											A/N	0.5	6.5
Vaccinium vitus-idaea						S-M/M-L	+												10.0	0.0
Valeriana septentrionalis*											+				A/M				5.3	22.3
Valeriana sitchensis			+					M/M											U	U
Zygadenus elegans																			5.0	38.0
Unidentified Forbs	M/M											+			M/L				5.0	13.0
																		+	5.0	38.0

Table 4. Abundance/caribou utilization of mosses and lichens at various sites in Jasper National Park, 1971-1973.
(For an explanation of the symbols used see Table 2)

Species	Alpine Tundra 7000' - 7500'				Alpine Tundra 7500'-8500'	Sub-alpine - Alpine Tundra 6500' - 7500'						Canadian Coniferous Zone 4500' - 6000'								
												Valley Bottom 4700' - 6000'						East Slope 6000'	Average Abundance (% cover)	Average Utilization (%)
	Marmot Basin (January 1972)	Marmot Basin (August 1972)	Campus Pass (August 1972)	Mt. Clitherow (August 1972)	Brazeau (John-John Creek) (August 1972)	Bald Hills (May 1972)	Bald Hills (1972-1973)	Snowbowl (October 1971)	Snowbowl (July 1972)	Evelyn Creek (July 1972)	Maligne Pass (July 1972)	Snake Indian (Blue Lake) (July 1972)	Sunwapta Falls (June 1972)	Buck Lake (June 1972)	Malinne Lake (March 1972)	Medicine Lake (May 1972, 1973)	Medicine Lake (January 1973)	"Old Burn" (Grizzly Flats) (June 1973)		
MOSSES																				
Aulacomnium palustre					+														U	U
Barbilophozia sp.												+							U	U
Dicranum sp.					S-A/N	+	+				+				M/L			+	5.2	6.5
Hylocomium sp.*																+			U	U
Lucobryum glaucum *					A/N-L										A/M				10.0	6.5
Pleurozium schreberi						S/N													10.0	38.0
Polytrichadelphus lanuginosum					M-A/N													+	0.5	0.0
Polytrichum sp.						+	+					M/L	+		S/N	+			7.5	0.0
Polytrichum juniperinum	M/U					A/H													2.8	6.5
Polytrichum piliferum															M/L				7.5	38.0
Ptilium crista-castrensis							+											+	5.0	13.0
Rhacomitrium sp.												M/L							U	U
Rhacomitrium canescens						A/M-H													5.0	13.0
Rhacomitrium lanuginosum																		+	10.0	57.0
Sphagnum sp.	M/H	S-A/N	M/N	A/N	M-A/N	M/L		M/M	A/N	M/H	A/N			+		S-M/N	+	M/N	U	U
Unidentified Mosses																			6.5	16.0
LICHENS																				
Alectoria sp.													+			+		M/M	5.0	38.0
Alectoria divergens	S/U																		0.5	U
Alectoria fremontii*							+												U	U
Alectoria glabra						+									M/L				5.0	13.0
Alectoria vexillifera					+														U	U
Cetraria sp.		+				+	+												U	U
Cetraria cucullata						+	+												U	U
Cetraria islandica	M/L	M/N				M-A/N-H	+												5.8	19.0
Cetraria pinastri															M/L			+	5.0	13.0
Cladina sp.*	+					+	+												U	U
Cladina arbuscula*															M/M				5.0	38.0
Cladonia sp.	S-M/U	M/N			S-M/N	+	+			S/N	M/N				M/M	+	+	M/N	3.7	6.3
Cladonia carneola							+												U	U
Cladonia cenotea							+						+					+	U	U
Cladonia chlorophaea																		+	U	U
Cladonia coniocraea																		+	U	U
Cladonia cornuta																		M/L	5.0	13.0
Cladonia deformis							+											M/L	5.0	13.0
Cladonia fimbriata													+						U	U
Cladonia gracilis							+						+					M/M	5.0	38.0
Cladonia mitis										A/M								+	10.0	38.0
Cladonia pleurota							+							+				+	U	U
Cladonia pyxidata	+													+					U	U
Cladonia rangiferina													+						U	U
Cladonia uncialis						+								+					U	U
Cladonia verticillata*																		+	U	U
Cornicularia aculeata						+													U	U
Dactylina arctica	+					+													U	U
Haematomma lapponicum						+													U	U
Letharia vulpina													+		S/N				0.5	0.0
Nephroma arcticum	S/U																	+	0.5	U
Parmeliopsis ambigua															M/N				5.0	0.0
Peltigera sp.	+	S/N			S-M/N						M/N								2.8	0.0
Peltigera aphthosa							+					S/N	+	+	U/H	+	+	M/N	2.8	25.3
Pertusaria dactylina						-													U	U
Physcia sp.*													+						U	U
Ramalina sp.							+												U	U
Stereocaulon sp.	+	S/N			+	M/N-L	+		S/N				+			+		+	3.0	2.2
Stereocaulon alpinum						M/U													5.0	U
Stereocaulon paschale										M/L									5.0	13.0
Thamnolia sp.					S/N		+									+			0.5	0.0
Thamnolia subuliformis	S/U					+								+				+	U	U
Thamnolia vermicularis					+														U	U
Usnea sp.													+		S/N				0.5	0.0
Unidentified Lichens																				
General	M/H				M/N			M/H					+			+			5.0	>0.6
Arboreal																	S/N		0.5	0.0
Crustose on rock		M/U				M-A/N						+						M/N	5.8	0.0

included 19 trees and shrubs, 32 graminoids, 8 horsetails and club-mosses, 106 forbs and low shrubs, 15 mosses and 45 lichens, for a total of 225 different plants.

Species or genera which provided at least 10% canopy coverage in the communities where they existed with their associated utilization (shown as % cover/% utilization), were:

Dryas integrifolia	10.0/38.0	*Lucobryum glaucum*	10.0/6.5
Luetkea pectinata	10.0/0.0	*Pleurozium scheberi*	10.0/38.0
Polygonum sp.	10.0/0.0	*Rhacomitrium lanuginosum*	10.0/57.0
Ranunculus sp.	10.0/0.0	*Cladonia mitis*	10.0/38.0
Vaccinium uliginosum	10.0/0.0	*Scirpus caespitosus*	10.0/0.0

Those plants providing from 5.0 to 9.5% canopy coverage and their associated utilization were:

Anemone occidentalis	5.1/0.0	*Phyllodoce* sp.	8.8/0.0
Cassiope mertensiana	8.3/12.7	*Phyllodoce empetriformis*	5.3/12.7
Cassiope tetragona	6.4/22.3	*Potentilla nivea*	5.0/38.0
Dryas sp.	5.6/6.5	*Selaginella densa*	5.0/38.0
Dryas octopetala	6.3/35.0	*Senecio resedifolius*	5.0/—
Erigeron aureus	5.0/0.0	*Senecio triangularis*	5.3/0.0
Juncus sp.	5.0/0.0	*Solidago* sp.	5.0/6.5
Linnaea borealis	5.0/38.0	*Vaccinium vitis-idaea*	5.3/22.3
Lomatium sp.	5.0/38.0	*Valeriana sitchensis*	5.0/38.0
Luzula sp.	5.0/0.0	*Zygadenus elegans*	5.0/13.0
Pedicularis arctica	5.0/76.0	*Dicranum* sp.	5.2/6.5
Petasites sp.	5.0/0.0	*Polytrichum* sp.	7.5/0.0
Betula sp.	5.0/38.0	*Polytrichum piliferum*	7.5/38.0
Betula glandulosa	5.0/13/0	*Ptilium cresta-castrensis*	5.0/13.0
Rosa acicularis	5.0/38.0	*Rhacomitrium canescens*	5.0/13.0
Salix arctica	5.1/6.5	*Alectoria* sp.	5.0/38.0
Salix barrattiana	5.0/0.0	*Alectoria glabra*	5.0/13.0
Salix glauca	7.5/0.0	*Cetraria nivalis*	5.8/19.0
Carex concinna	5.0/38.0	*Cetraria pinastri*	5.0/13.0

Carex nigricans	5.0/0.0	*Cladina arbuscula*	5.0/38.0
Carex scirpoidea	7.5/25.5	*Cladonia cornuta*	5.0/13.0
Poa alpina	5.0/—	*Cladonia deformis*	5.0/13.0
Equisetum sp.	5.0/6.5	*Cladonia gracilis*	5.0/38.0
Equisetum scirpoides	7.5/57.0	*Parmeliopsis ambigua*	5.0/0.0
Lycopodium sp.	5.0/0.0	*Stereocaulon alpinum*	5.0/—
		Stereocaulon paschale	5.0/13.0

Table 5 shows the relative abundance and utilization plus diet preference index (utilization ÷ cover) for the 52 species which contributed the bulk of yearlong caribou diet. A checklist of 187 species identified from these ranges is shown in Appendix I. These species included 66 forbs, 35 trees and shrubs, 29 graminoids, 6 horsetails and club-mosses, 38 lichens and 13 mosses.

The 20 most preferred forage species (% utilization ÷ % cover) in decreasing order of preference were *Bromus marginatus, Carex albonigra, Pedicularis arctica, Peltigera apthosa, Cladina arbuscula, Equisetum scirpoides, Valeriana sitchensis, Lomatium* sp., *Linnaea borealis, Carex concinna, Potentilla nivea, Senecia resedifolius, Phyllodoce glanduliflora, Rhacomitrium lanuginosum, Dryas octopetala, Caltha leptosepala, Polytrichum piliferum, Arctostaphylos uva-ursi, Trollius albiflorus* and *Abies lasiocarpa.*

A measure of the degree to which each of the 52 most abundant species contributed to the yearlong diet can be obtained by multiplying % cover x % utilization (Table 5). By this method, the 10 plants contributing the most to caribou summer diet were found to be: *Rhacomitrium lanuginosum* (5.70%), *Equisetum scirpoides* (4.27%), *Pleurozium schreberi* (3.80%), *Pedicularis arctica* (3.80%), *Dryas integrifolia* (3.80%), *Polytrichum piliferum* (2.85%), *Betula glandulosa* (2.55%),

Table 5. Relative abundance, utilization, % diet and preference index for 52 plant species comprising most of the caribou yearlong diet in Jasper National Park.

Forage Species	% Cover	% Utiliz.	% Diet (Cover x Utiliz.)	Preference Index (Utiliz. ÷ Cover
		TREES AND SHRUBS		
Abies lasiocarpa	4.0	17.8	0.71	4.4
Arctostaphylos uva-ursi	3.8	19.0	0.07	5.0
Betula glandulosa & spp.	10.0	25.5	2.55	2.5
Cassiope mertensiana	8.3	12.7	1.05	1.5
Cassiope tetragona	6.4	22.3	1.43	3.5
Dryas integrifolia	10.0	38.0	3.80	3.8
Dryas octopetala	6.3	35.0	2.20	5.6
Empetrum nigrum	4.6	8.0	0.37	1.7
Ledum groenlandicum	3.5	12.7	0.44	3.6
Menziesia glabella	-	38.0	-	-
Phyllodoce empetriformis	5.3	12.7	0.67	2.4
Phyllodoce glanduliflora	3.7	25.3	0.94	6.8
Potentilla nivea	5.0	38.0	1.90	7.6
Salix arctica	5.1	6.5	0.33	1.3
Salix nivalis	3.4	12.8	0.44	3.8
Senecio resedifolius & spp.	5.5	38.0	2.09	6.9
Solidago multiradiata	5.0	6.5	0.32	1.3
Vaccinium vitis-idaea	5.3	22.3	1.18	4.2
		GRAMINOIDS		
Bromus marginatus	0.5	13.0	0.06	26.0
Carex albo-nigra	2.8	44.5	1.25	15.9
Carex concinna	5.0	38.0	1.90	7.6
Carex scirpoidea	7.5	22.5	1.91	3.4
Carex spectabilis	10.0	13.0	1.30	1.3
Festuca brachyphylla	2.8	6.5	0.18	2.3
Phleum alpinum	2.8	6.5	0.18	2.3
Trisetum spicatum	3.9	3.3	0.13	0.8

Table 5. (continued)

Forage Species	% Cover	% Utiliz.	% Diet (Cover x Utiliz.)	Preference Index (Utiliz. ÷ Cover)
		FORBS		
Caltha leptosepala	4.3	23.3	1.00	5.4
Linnaea borealis	5.0	38.0	1.90	7.6
Lomatium sp.*	5.0	38.0	1.90	7.6
Pedicularis arctica	5.0	76.0	3.80	15.2
Valeriana sitchensis	5.0	38.0	1.90	7.6
Zygadenus elegans	5.0	13.0	0.65	2.6
Trollius albiflorus	3.9	19.0	0.74	4.9
		HORSETAILS, CLUB-MOSSES & MOSSES		
Equisetum scirpoides	7.5	57.0	4.27	7.6
Dicranum scoparium	5.2	6.5	0.34	1.2
Lucobryum glaucum	10.0	6.5	0.65	0.6
Pleurozium schreberi	10.0	38.0	3.80	3.8
Polytrichum piliferum	7.5	38.0	2.85	5.1
Ptilium crista-castrensis	5.0	13.0	0.65	2.6
Rhacomitrium canescens	5.0	13.0	0.65	2.6
Rhacomitrium lanuginosum	10.0	57.0	5.70	5.7
		LICHENS		
Alectoria glabra	5.0	13.0	0.65	2.6
Cetraria nivalis	5.8	19.0	1.10	3.3
Cetraria pinastri	5.0	13.0	0.65	2.6
Cladina arbuscula	5.0	38.0	1.90	7.6
Cladonia cornuta	5.0	13.0	0.65	2.6
Cladonia deformis	5.0	13.0	0.65	2.6
Peltigera apthosa	2.8	25.3	1.98	9.0
Stereocaulon paschale	5.0	13.0	0.65	2.6

* This genus probably incorrect.

Dryas octopetala (2.20%), *Senecio resedifolius* (2.09%), *Peltigera apthosa* (1.98%).

Plant species and the parts of each species used in Fellfield Tundra, Mountain Heather, Alpine Meadow and Lower Krummholz habitats are shown in Table 6. Flowers were the preferred portion of forbs during summer compared to leaves, stems and occasionally roots of shrubs, and leaves of graminoids.

The occurrence and utilization of major plant species at the Medicine Lake delta and the Maligne Lake coniferous forest are presented in Tables 7 and 8.

On the Medicine Lake delta, vegetation production was 637.40 kg/ha comprised of 83.7% *Equisetum variegatum* and 16.3% graminoids. Graminoids, especially *Carex* spp. and *Poa polustris* occurred on 55.7% of the plots with an average utilization of 25.1%; horsetails *(Equisetum variegatum)* occurred on 50.2% of the plots with an average utilization of 38.3%. Although mosses occurred on 10.5% of the plots, utilization was not observed.

Vegetation on the coniferous forest range east of Maligne Lake consisted of 4 shrub, 3 graminoid, 7 forb, 1 horsetails, 13 lichen and 4 moss species. The understory vegetation consisted of 29.5% forbs, 26.9% lichens, 17.5% mosses, 16.7% graminoids, 7.7% shrubs and 1.7% horsetails. A measure of the contribution each species made to the diet was determined by multiplying % frequency of occurrence x % utilization. The 12 species which provided most of the diet, in decreasing order of importance, were: *Peltigera apthosa, Vaccinium vitus-idaea, Cladina arbuscula, Ledum groenlandicum, Bromus marginatus, Arctostaphylos uva-ursi, Linnaea borealis, Cladonia* spp., *Equisetum scirpoides, Carex concinna, Rosa acicularis* and *Pleurozium schreberi.*

Table 6. Plant species utilized at caribou feeding sites in Evelyn and Maccarib creeks watersheds, August 1973.

Ecosystem/Plant Community	Locations	Elevation	Plant Species Used	Percentage of Plant Used	Part of Plant Used
			FELLFIELD TUNDRA		
Dryas octopetala	Evelyn Creek Watershed	7400 ft. (2256 m)	*Silene acaulis*	25	top and roots
			Potentilla nivea	-	
			Arctostaphylos uva-ursi	-	
Dryas octopetala-Salix spp.	Evelyn Creek Watershed	7000 ft. (2134 m)	*Salix* spp.	5	terminal leaves
			MOUNTAIN HEATHER		
Phyllodoce-Cassiope	Evelyn Creek Watershed	7200 ft. (2195 m)	*Pedicularis bracteosa*	33	flowers
			Phyllodoce sp.	40	leaves
			Cassiope tetragona	40	leaves
Phyllodoce-Cassiope	Maccarib Creek Watershed	7100-7400 ft. (2164m-2256 m)	*Anemone occidentalis*	75	achenes
			Carex spp.	100	leaves
			Artemisia norvegica	40	flowers
			Erigeron sp.	100	flowers
			Carex nigricans	100	leaves
			ALPINE MEADOW		
Herb-moss	Evelyn Creek Watershed	7000 ft. (2134 m)	*Pedicularis bracteosa*	50	flowers
			Oxyria digyna	80	flowers
Anemone occidentalis-Artemesia norvegica		7100 ft. (2164 m)	*Antennaria lanata*	20	flowers
			Castilleja septentrionalis	65	flowers
	Maccarib Creek Watershed	7100 ft. (2164 m)	*Carex* spp.	50	stems and leaves
			Artemisia norvegica	50	stems and leaves
			Salix spp.	5	leaves
			Caltha leptosepala	10	stems
			Pedicularis bracteosa	100	flowers
Lower Krummholz	Maccarib Creek Watershed	7100 ft. (2164 m)	*Valeriana sitchensis*	60	flowers
			Erigeron sp.	100	flowers
			Grass	25	leaves
			Pedicularis groenlandica	100	flowers

Table 7. Occurrence and utilization* of plant species at the Medicine Lake delta, May 1972-1974.

Plant Species	PERCENT OCCURRENCE & UTILIZATION (MAY, 1972-1974) 1972 % Occur.	1972 % Util.	1973 % Occur.	1973 % Util.	1974 % Occur.	1974 % Util.	Averages % Occur.	Averages % Util.	BIOMASS Dry wt. (kg/ha)	BIOMASS Total Biomass %
					GRAMINOIDS					
All Graminoids			64.0	36.2			55.7	25.1	103.9	16.3
Carex spp.	1.9	-	-	-	1.3	0.0				
Poa paludtris	0.0	-	-	-	38.0	14.0				
Other grasses	61.8	-	-	-	-	-				
					HORSETAILS					
*Equisetum spp.***	81.3	-	31.2	24.0	38.0	52.6	50.2	38.3	533.5	83.7
					MOSSES AND CLUB-MOSSES					
	30.5	-	0.3	0.0	0.7	0.0	10.5	0.0	0.0	0.0
					BARE GROUND					
	-	-	4.5	0.0	22.0	0.0	13.3	0.0	-	-

* as in Table 2.

** *Equisetum scirpoides* and *E. variegatum*

Table 8. Frequency of occurrence and utilization of plants in caribou winter feeding craters, Maligne Lake, March 1973.

Species	Frequency of Occurrence (out of 36 craters)		Utilization		
	No.	%	No.	%	Utilization class*
		TREES AND SHRUBS			
Juniperus communis	12	33.3	2	16.7	light
Rosa acicularis	5	13.9	4	80.0	heavy
Shepherdia canadensis	1	2.8	1	100.0	heavy
Vaccinium vitus-idaea	23	63.9	10	43.4	moderate
		GRAMINOIDS			
Bromus marginatus	29	80.6	8	27.6	moderate
Carex concinna	9	25.0	4	44.4	moderate
Deschampsia caespitosa	1	2.8	1	100.0	heavy
		FORBS			
Achillea millefolium	1	2.8	0	0.0	nil
Arctostaphylos uva-ursi	10	27.8	7	70.0	heavy
Fragaria virginiana	2	5.6	0	0.0	nil
Ledum groenlandicum	16	44.4	8	50.0	moderate
Linnaea borealis	12	33.3	7	58.3	heavy
Solidago multiradiata	1	2.8	1	100.0	heavy
Zygadenus elegans	4	11.1	1	25.0	light
		HORSETAILS			
Equisetum scirpoides	4	11.1	4	100.0	heavy
		LICHENS			
Alectoria glabra	3	8.3	1	33.3	moderate
Cetraria pinastri	7	19.4	1	14.3	light
Cladina arbuscula	11	30.6	9	81.9	heavy
Cladonia spp.**	14	38.3	5	35.7	moderate
Letharia vulpina	1	2.8	0	0.0	nil
Parmeliopsis ambigua	6	16.7	0	0.0	nil
Peltigera aphthosa	20	55.6	17	85.0	heavy
Usnea sp.	1	2.8	0	0.0	nil
		MOSSES			
Dicranum sp.	16	44.4	1	6.3	light
Pleurozium schreberi	20	55.6	3	15.0	light
Polytrichum juniperinum	1	2.8	0	0.0	nil
Ptilium crista-castrensis	4	11.1	1	25.0	light

* As used in Tables 1 - 3

**Includes *Cladonia cornuta, C. fimbriata, C. pyxidata, C. verticillata, C. ecmocyna* and *Cladonia* sp.

Caribou diet on a krummholz range at Marmot Basin in January consisted mainly of lichens and mosses, followed by forbs, with light use of *Dryas octopetala*, *Carex* spp. and *Picea engelmannii* (Table 9).

During July along a broad subalpine valley near Maligne Pass, caribou were feeding extensively on *Caltha leptosepala* and *Pedicularis arctica* in the mesic depressions between hummocks (Table 10). They also fed extensively on *Salix arctica* both on and between hummocks, and fed lightly on *Solidago multiradiata* on the hummocks. Foraging concentrated on species in the early stage of growth and those in flower.

4.1.3 Species distributions by vegetation zones and soil moisture.

The affinity of plant species for either xeric or mesic sites within Alpine-Tundra Meadow, Open Engelmann Spruce Forest, and Lower and Upper Krummholz communities along the Maccarib Valley is displayed in Tables 11 and 12. These tables reveal the preference of *Cassiope*, *Phyllodoce*, *Arctostaphylos*, *Silene*, *Artemisia*, *Pedicularis*, *Erigeron*, *Salix* and *Equisetum* spp. for mesic sites and the preferernce for xeric sites of *Anemone*, *Caltha*, *Oxyria*, *Senecio* and moss species.

Some species such as *Cassiope tetragona* and *Anemone occidentalis* were common in the Lower Krummholz zone but not in the Upper Krummholz or Open Engelmann Spruce Forest zones (Table 11). *Juniperus*, *Phyllodoce*, *Epilobium veronica* and moss species were more common in the Open Engelmann Spruce Forest, whereas *Arctostaphylos*, *Dryas*, *Senecio*, *Sibbaldia*, *Valeriana*, *Carex*, *Poa*, *Equisetum* and *Lycopodium* spp. plus *Anemone drummondii* and *Pedicularis bracteosa* were more common in the Upper Krummholz zone.

Table 9. Occurrence and utilization of plants in caribou winter feeding craters, Marmot Basin, January 1972.

Species	Abundance	Utilization			
		Nil	Light	Moderate	Heavy
Lichens and mosses	moderate				X
Cassiope spp.	abundant	-	-	-	-
Dryas octopetala	moderate		X		
Sedges and grasses	scarce		X		
Festuca sp.	scarce	X			
Picea engelmannii	moderate		X		
Pinus albicaulis	scarce	X			
Pedicularis sp.	moderate			X	
Other forbs	moderate			X	

Table 10. Occurrence and utilization* of 304 plants (on and between hummocks) at a caribou feeding site near Maligne Pass, July 1972.

	Overall Occurrence (%)	Overall Utilization (%)	Between Hummocks		On Hummocks	
			% Utilized	% Not Utilized	% Utilized	% Not Utilized
			SHRUBS			
Cassiope mertensiana	4.3	0.0	0.0	100.0	0.0	100.0
Salix arctica	9.2	10.7	11.1	88.9	10.5	89.5
			GRAMINOIDS			
Carex nigricans	6.3	0.0	0.0	100.0	0.0	100.0
Luzula sp.	3.3	0.0	- ***	-	0.0	100.0
			FORBS			
Anemone occidentalis	2.6	0.0	0.0	100.0	0.0	100.0
Antennaria lanata	3.6	0.0	0.0	100.0	0.0	100.0
Caltha leptosepala	6.9	61.9	61.9	38.1	-	-
Kalmia microphylla	0.3	0.0	-	-	0.0	100.0
Luetkea pectinata	20.7	0.0	0.0	100.0	0.0	100.0
Pedicularis arctica	1.6	100.0	0.0	100.0	-	-
Petasites sp.	1.6	0.0	0.0	100.0	-	-
Ranunculus eschscholtzii	0.3	0.0	0.0	100.0	-	-
Senecio triangularis	0.3	0.0	0.0	100.0	-	-
Solidago multiradiata	5.3	6.3	0.0	100.0	9.1	90.9
Trollius laxus	0.3	0.0	6.0	100.0	-	-
			MOSSES AND LICHENS			
Cladonia sp.	6.3	0.0	0.0	100.0	0.0	100.0
Mosses**	19.4	0.0	0.0	100.0	0.0	100.0
Peltigera sp.	7.6	0.0	0.0	100.0	0.0	100.0

* Obtained by point-intercepts along a transect (elevation 2130m)
**Includes *Dicranum* sp., *Aulacomnium palustre*, *Hylocomium splendens* and *Barbilophozia* sp.
***Means the species did not occur there

Table 11. Percent cover of plants in three vegetation zones on the north side of Maccarib Creek, August 1973.

	Percent Cover from 400 cm^2 Plots			% Distribution	
	Open Engelmann Spruce Forest	Lower Krummholz	Upper Krummholz	Xeric Sites	Mesic Sites
Elevation (metres)	2120	2165	2225		
Slope - xeric sites	10 - 30%	15 - 40%	10 - 50%		
- mesic sites	0 - 5%	0 - 10%	5 - 10%		
Aspect	S	S	S		
		SHRUBS			
Juniperus sp.	1.5	0.0	0.0	100	0
Salix arctica	0.0	2.5	2.0	100	0
		DWARF SHRUBS			
Arctostaphylos sp.	0.0	0.0	0.5	100	0
Cassiope tetragona	0.0	11.0	0.0	45	55
Dryas hookeriana	0.0	0.0	22.0	100	0
Phyllodoce sp.	19.5	16.0	3.0	82	18
Vaccinium scoparium	3.9	7.5	1.0	39	61
		FORBS			
Anemone drummondii	0.0	0.0	6.8	12	88
Anemone occidentalis	3.5	15.0	0.0	3	97
Antennaria lanata	4.0	3.5	4.5	17	83
Artemisia norvegica	11.0	13.0	14.5	21	79
Epilobium latifolium	1.0	0.0	0.0	100	0
Erigeron sp.	3.0	0.0	2.7	21	79
Pedicularis bracteosa	0.0	0.0	2.0	100	0
Pedicularis groenlandica	0.0	0.5	0.0	0	100
Potentilla sp.	0.0	1.7	1.5	100	0
Senecio triangularis	0.5	0.0	4.0	0	100
Sibbaldia sp.	0.0	0.2	0.5	29	71
Valeriana sitchensis	6.0	7.5	8.5	0	100
Veronica sp.	0.8	0.0	0.0	0	100
		GRAMINOIDS			
Carex sp.	2.0	2.0	8.7	5	95
Poa arctica	0.0	0.0	4.5	0	100
Unidentified	1.5	0.0	0.0	0	100
		LICHENS, MOSSES, CLUB-MOSSES			
Equisetum sp.	0.0	0.0	3.0	100	0
Lichens	6.5	9.0	5.5	86	14
Lycopodium sp.	0.0	1.0	1.5	40	60
Mosses	41.5	34.0	28.0	45	55
		OTHERS			
Picea engelmannii cone	0.4	0.0	0.0	0	100
Bare ground/rock	9.8	0.0	0.0	100	0

Table 12. The affinity of alpine-tundra meadow* species for xeric or mesic sites, north side of Maccarib Creek, August 1973.

	Xeric Sites		Mesic Sites	
	Average Cover (%) (5 plots)	Percentage of Total Distribution	Average Cover (%) (10 plots)	Percentage of Total Distribution
	SHRUBS			
Salix barrattiana	12.0	44.0	15.0	56.0
Salix spp. (dwarf)	5.4	72.0	2.1	28.0
	DWARF SHRUBS			
Arctostaphylos sp.	6.0	92.0	0.5	8.0
Cassiope sp.	4.0	100.0	0.0	0.0
Phyllodoce sp.	18.4	100.0	0.0	0.0
	HERBS			
Anemone drummondii	0.0	0.0	3.0	100.0
Anemone occidentalis	2.0	9.0	21.0	91.0
Artemisia norvegica	3.0	86.0	0.5	14.0
Caltha leptosepala	0.0	0.0	10.0	100.0
Erigeron sp.	4.0	80.0	1.0	20.0
Oxyria digyna	0.0	0.0	2.5	100.0
Pedicularis groenlandica	1.0	83.0	0.2	17.0
Senecio triangularis	0.0	0.0	2.0	100.0
Silene acaulis	3.0	100.0	0.0	0.0
	OTHERS			
Carex sp.	22.0	70.0	9.6	30.0
Equisetum sp.	0.8	62.0	0.5	38.0
Mosses	53.0	35.0	100.0	65.0

* Elevation = 2165 m, Slope = 10%, Aspect = south.

4.1.4 Caribou diet from fecal and rumen analysis

4.1.4.1 Fecal analysis

Table 13 shows the percent relative density of forage species in caribou diet by months for the years 1971-1973.

Graminoids formed 18.4% of the diet for the period May-October, with the highest use in July (34.8%).

Large shrubs and trees formed a slightly higher percentage of the diet (19.4%) with the highest use for the May-October period occurring on August (27.7%).

Forbs and low shrubs formed less than 10% of the May-October diet (6.0%) with the highest use in August (8.5%).

Lichens, mosses (including club-mosses) and horsetails formed over half the diet during the spring-fall period (56.2%), comprising more than 80% of the diet during May, June and October. These results indicate that caribou fed heavily on lichens, mosses and horsetails during spring and fall, with graminoids averaging 26.5% of the diet during the summer months of July and August. According to Dearden et al. (1972) mosses are highly overestimated in rumen and fecal analysis techniques due to the fact that mosses fragment more than other plants and even extremely small fragments are easily identified. They suggest that perhaps mosses should be ignored in botanical composition of rumen and fecal material because of their high degree of over-estimation and the observation that they are not digestible in reindeer, cattle or bison. Large trees and shrubs did not contribute significantly to the diet during spring and fall, but did provide 23.1% of the summer (July-August) diet.

The following three plant species or groups provided 73.6% of the July-August diet:

Cladonia type	27.1%
Carex spp.	24.5%
Salix spp.	22.0%

Six other species which contributed more than 1.0% to the spring-fall diet were: *Equisetum* spp. (3.2%), *Dryas* spp. (2.7%), *Festuca* spp. (2.1%), *Abies lasiocarpa* (1.6%), *Astragalus* spp. (1.4%) and *Potentilla* spp. (1.3%).

Table 14 compares monthly diet composition for various ranges and provides some interesting results. For example during May, caribou on and near the Medicine Lake delta fed heavily on *Cladonia* lichens (40.7%), *Equisetum* spp. (22.9%), mosses (17.0%), *Festuca* spp. (8.5%) and *Carex* spp. (3.3%). On the subalpine and alpine-tundra range in the Bald Hills in May, caribou also fed primarily on *Cladonia* lichens (55.2%) and mosses (22.2%), but in addition fed extensively on *Dryas* spp. (13.0%), less on *Festuca* spp. (2.4%), not at all on *Equisetum* spp. and only lightly on *Carex* spp. (0.1%). Forbs and low shrubs contributed significantly to the May diet on the Bald Hills (13.0%) but were insignificant in the caribou diet at the delta. The same discrepancy was apparent in June where the diet for caribou on the low-elevation burn along the Sunwapta Valley was compared to that for caribou on the subalpine and alpine-tundra range along the Skyline Trail. *Cladonia* lichens, mosses and *Abies lasiocarpa* formed almost all of the diet on the Sunwapta burn, with lichens, mosses and horsetails providing 97.7%. Conversely, on the higher Skyline Range they only provided 52.6% of the

Table 13. Percent relative density of forage species in caribou diet by month, 1971-73, from fecal analysis.

Species	May	June	July	August	October	May-Oct.
			GRAMINOIDS			
Agropyron spp.	0.01	0.00	0.00	0.01	0.00	0.01
Bromus spp.	0.10	0.00	0.03	0.05	0.00	0.05
Carex spp.	2.47	1.16	31.65	17.27	4.16	16.20
Festuca spp.	6.86	0.17	2.10	0.99	1.04	2.08
Juncus spp.	0.00	0.00	0.18	0.42	0.07	0.26
Phleum alpinum	0.00	0.00	0.00	Tr.*	0.00	Tr.
Poa spp.	0.00	0.00	0.00	Tr.	0.00	Tr.
Trisetum spicta	0.00	0.00	0.00	0.03	0.00	0.01
Unknown grass	0.00	0.00	0.01	Tr.	0.00	0.01
Graminoid Aves.	9.50	1.33	34.84	18.22	5.27	18.43
			LARGE SHRUBS & TREES			
Abies lasiocarpa	4.66	2.58	2.51	0.21	0.44	1.62
Picea spp.	0.10	0.00	0.00	0.00	0.00	0.02
Juniperus spp.	0.00	0.02	0.00	0.00	0.00	Tr.
Salix spp.	1.03	1.31	15.55	28.35	1.33	17.96
Shepherdia canadensis	0.02	0.00	0.00	0.00	0.00	Tr.
Shrub & Tree Aves.	5.85	3.91	18.52	27.72	1.77	19.40
			FORBS & LOW SHRUBS			
Artemisia spp.	0.05	4.85	0.00	0.01	0.00	0.44
Astragalus spp.	0.00	0.14	0.04	2.63	1.20	1.38
Cassiope spp.	0.00	0.00	0.02	0.01	0.00	0.01
Draba spp.	0.00	0.00	0.00	Tr.	0.00	Tr.
Empetrum nigrum	0.02	0.00	0.03	Tr.	0.00	0.01
Linnaea borealis	0.02	0.00	0.04	0.04	0.00	0.02
Potentilla spp.	0.12	0.00	0.96	2.52	0.07	1.33
Vaccinium spp.	0.00	0.00	0.00	0.01	0.00	0.01
Unknown composite	0.00	0.00	0.03	0.11	0.00	0.06
Unknown Ericacae	0.03	0.00	0.01	0.16	0.00	0.08
Unknown forbs	0.01	0.00	0.00	0.05	0.00	0.03
Dryas spp.	3.60	0.01	2.14	3.27	1.78	2.73
Forb, Low Shrub Aves.	3.87	5.00	3.35	8.55	3.05	6.03
			LICHENS, MOSSES, CLUB-MOSSES, HORSETAILS			
Moss	18.41	12.81	13.27	19.78	21.87	17.61
Equisetum spp.	16.82	1.04	0.39	0.83	0.50	3.23
Cetaria type	0.00	0.00	0.17	0.43	0.57	0.28
Cladonia type	44.60	75.46	28.32	25.83	66.79	35.15
Peltigera apthosa	0.47	0.44	0.12	0.75	0.17	0.52
Aves.	80.78	89.76	43.35	46.23	89.90	56.22

* Tr. = trace, or < 0.01%.

Table 14. Percent relative density of forage fragments from 193 caribou fecal samples from five monthly periods, 1971-73.

Forage Species	MAY (30)				JUNE (17)						JULY
	Medicine L (22)		Bald Hills (8)		Sunwapta (14)		Skyline (3)		Skyline (17)		Maligne Pa
	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total
Agropyron spp.	0.30	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bromus spp.	2.97	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Carex spp.	72.90	3.31	1.23	0.15	12.91	0.92	6.85	2.28	626.95	36.88	547.77
Festuca spp.	186.91	8.50	18.95	2.37	1.78	0.13	1.13	0.38	44.54	2.62	31.13
Juncus spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.39	0.14	3.47
Phleum alpinum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poa spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Trisetum spicatum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unknown Grass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals & Aves.	263.08	12.05	20.18	2.52	14.69	1.05	7.98	2.66	673.92	39.64	582.37
Abies lasiocarpa	90.68	4.12	49.14	6.14	16.89	1.20	26.95	8.98	2.22	0.13	0.71
Picea spp.	2.74	0.12	0.26	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Juniperus spp.	0.00	0.00	0.00	0.00	0.26	0.02	0.00	0.00	0.00	0.00	0.00
Salix spp.	31.09	1.41	0.00	0.00	0.00	0.00	22.27	7.42	380.19	22.36	10.25
Shepherdia canadensis	0.73	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Totals & Aves.	125.24	5.74	49.40	6.18	17.15	1.23	49.22	16.41	382.41	22.49	10.96
Artemisia spp.	1.48	0.07	0.00	0.00	0.00	0.00	82.47	27.49	0.00	0.00	0.00
Astragalus spp.	0.00	0.00	0.00	0.00	0.00	0.00	2.31	0.77	1.05	0.06	0.00
Cassiope spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.06	0.00
Draba spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Empetrum nigrum	0.36	0.02	0.34	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Linnaea borealis	0.00	0.00	0.72	0.09	0.00	0.00	0.00	0.00	1.06	0.06	0.00
Potentilla spp.	3.72	0.17	0.00	0.00	0.00	0.00	0.00	0.00	8.01	0.47	0.40
Vaccinium spp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unk. composite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71
Unk. Ericaceae	0.84	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unk. forb	0.39	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dryas spp.	3.87	0.18	104.11	13.01	0.00	0.00	0.24	0.38	4.51	0.27	84.84
Totals & Aves.	10.66	0.49	105.17	13.15	0.00	0.00	85.02	28.34	15.63	0.92	85.95
Moss	374.95	17.04	177.34	22.17	131.18	9.37	86.54	28.85	285.83	16.81	108.01
Equisetum spp.	504.74	22.94	0.00	0.00	12.87	0.92	4.90	1.63	10.78	0.63	3.17
Cetaria type	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.42	0.26	0.52
Cladonia type	896.27	40.74	441.73	55.22	1218.41	87.03	64.54	21.51	322.23	18.95	208.31
Peltigera apthosa	8.00	0.36	6.18	0.77	5.70	0.41	1.80	0.60	3.39	0.20	0.71
Totals & Aves.	1783.96	81.72	625.25	78.16	1368.16	97.73	157.78	52.59	626.65	36.86	320.72

*Tr = trace, or <0.01%

Blue Lake (15)		Marmot Mtn. (18)		Camous Pass and Mt. Clitheroe (17)		AUGUST (97) Skyline (35)		Haccarib Pass (9)		Brazeau (18)		OCTOBER (7) Skyline (7)		MAY - OCT. Averages (193)	
Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.	Total	Ave.
GRAMINOIDS															
0.00	0.00	0.00	0.00	0.00	0.00	0.74	0.02	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.01
1.37	0.09	0.00	0.00	0.00	0.00	1.89	0.05	0.00	0.00	3.41	0.19	0.00	0.00	9.64	0.05
154.70	10.31	9.20	0.51	188.17	11.06	963.01	27.51	214.00	23.77	300.81	16.71	29.13	4.16	3127.67	16.20
12.89	0.86	16.50	0.92	5.91	0.35	31.55	0.90	2.40	0.27	40.09	2.22	7.29	1.04	401.07	2.08
1.88	0.13	0.00	0.00	13.30	0.78	4.32	0.12	4.24	0.47	19.24	10.68	0.50	0.07	49.34	0.26
0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.40	Tr.*
0.00	0.00	0.00	0.00	0.67	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.67	Tr.
0.00	0.00	0.00	0.00	0.00	0.00	1.77	0.05	0.00	0.00	0.74	0.04	0.00	0.00	2.51	0.01
0.50	0.03	0.00	0.00	0.00	0.00	0.26	0.01	0.50	0.06	0.00	0.00	0.00	0.00	1.26	0.01
171.34	12.23	25.70	1.43	208.05	12.24	1003.94	28.64	221.14	24.57	364.29	17.05	36.92	5.27	3593.60	18.41
LARGE SHRUBS & TREES															
102.61	6.84	2.00	0.11	4.47	0.26	11.95	0.34	0.00	0.00	2.18	0.12	3.08	0.44	312.88	1.62
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.02
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	Tr.
262.77	17.52	0.58	0.03	912.56	53.68	668.05	19.08	484.23	53.80	684.36	38.02	9.32	1.33	3465.67	17.96
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73	Tr.
365.38	26.08	2.58	0.14	917.03	53.94	680.00	19.40	484.23	53.80	686.54	32.15	12.40	1.77	3782.54	19.38
FORBS & LOW SHRUBS															
0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.03	0.00	0.00	0.00	0.00	0.00	0.00	85.06	0.44
0.48	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	254.73	14.11	8.40	1.20	266.97	1.38
0.00	0.00	0.36	0.02	0.00	0.00	0.58	0.02	0.00	0.00	0.36	0.02	0.00	0.00	2.30	0.01
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.03	0.00	0.00	0.53	Tr.
1.09	0.07	0.58	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.37	0.01
0.57	0.04	0.00	0.00	0.67	0.04	0.73	0.02	0.00	0.00	0.46	0.03	0.00	0.00	4.21	0.02
32.07	2.14	0.00	0.00	2.39	0.14	53.31	1.52	18.55	2.06	138.31	7.68	0.50	0.07	257.26	1.33
0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.01
0.54	0.04	0.31	0.02	0.00	0.00	6.99	0.20	0.00	0.00	2.70	0.15	0.00	0.00	11.25	0.06
0.59	0.04	10.42	0.58	0.00	0.00	0.00	0.00	0.00	0.00	4.31	0.24	0.00	0.00	16.16	0.08
0.00	0.00	0.31	0.02	0.41	0.02	4.76	0.14	0.00	0.00	0.00	0.00	0.00	0.00	5.87	0.03
0.62	0.04	92.17	5.12	11.61	0.68	72.17	2.01	32.36	3.60	108.42	6.02	12.48	1.78	527.40	2.73
35.96	2.57	104.15	5.79	15.08	0.89	140.65	4.02	50.91	5.66	509.82	23.88	21.38	3.05	1180.38	6.05
LICHENS, MOSSES, CLUB-MOSSES & HORSETAILS															
163.63	10.91	548.59	30.48	255.97	15.06	732.34	20.92	66.15	7.35	315.70	17.53	153.11	21.87	3399.34	17.61
2.26	0.15	0.00	0.00	24.42	1.44	2.36	0.07	16.16	1.80	37.57	2.08	3.47	0.50	622.70	3.23
2.14	0.14	0.41	0.02	3.24	0.19	4.89	0.14	22.89	2.54	10.96	0.61	3.96	0.57	53.43	0.28
659.31	43.95	1065.71	59.21	276.21	16.25	920.11	26.28	38.52	4.28	205.84	11.43	467.56	66.79	6784.75	35.15
0.98	0.06	52.86	2.94	0.00	0.00	15.03	0.43	0.00	0.00	4.71	0.26	1.20	0.17	100.56	0.52
828.32	59.12	1667.57	92.64	559.84	32.93	1674.73	47.85	143.72	15.97	574.78	26.92	629.30	89.90	10960.78	56.16

diet, while *Artemisia* spp. contributed heavily (27.5%), as did *Abies lasiocarpa* (9.0%), *Salix* spp. (7.4%) and *Carex* spp. (2.3%).

In July, the diet of caribou along the Montane and subalpine Blue Lake Valley consisted primarily of lichens, mosses and horsetails (59.1%), *Salix* spp. (17.5%), *Carex* spp. (10.3%) *Abies lasiocarpa* (6.8%) and *Potentilla* spp. (2.1%). During the same month caribou on the subalpine and alpine-tundra ranges along the Skyline and the Maligne Pass fed less on lichens, mosses and horsetails (34.4%), and more on *Carex* spp. (45.8%) *Dryas* spp. (4.4%) and *Festuca* spp. (2.9%)

In August, all five ranges were in subalpine and alpine-tundra phytogeographic regions (life zones). Although lichens, mosses, and horsetails predominated in the overall diet, large shrubs and trees, especially *Salix* spp., formed a major portion of the diet on the Campus Pass-Mt. Clitheroe (53.9%) and Maccarib Pass (53.8%) ranges. Graminoids, especially *Carex* spp. contributed 28.6 and 24.6% of the diet on the Skyline and Maccarib Pass ranges, respectively, and 17.0 and 12.2% on the Brazeau and Campus Pass-Mt. Clitheroe ranges, respectively. The diet of caribou on Marmot Mtn. differed in that it contained only a small amount of graminoids (1.4%) plus large shrubs and trees (0.1%) but a much higher proportion of lichens, mosses and horsetails (92.6%).

The diet of caribou along the Skyline changed significantly throughout the May-October period. Whereas graminoids were unimportant in June (2.7%), they became important in July (39.6%) and August (28.6%) then declined to low importance in October (5.3%). Large shrubs and trees, especially *Salix* spp. and *Abies lasiocarpa*, provided 16.4 to 22.5% of the diet during June-August, then declined to only 1.8% of the diet

in October. Forbs and low shrubs, especially *Artemisia* spp., provided less than 5.0% of the diet except during June (28.3%). *Potentilla* spp. were only important in July (0.5%) and August (1.5%) whereas *Astragalus* spp. were important in June (0.8%) and October (1.2%). Lichens, mosses and horsetails provided 32.0 and 89.0% of the June-October diet and were most important in June (52.6%) and October (89.9%). *Cladonia*-type lichens plus mosses were especially important during that period.

A comparison of important forage species in May and June on low-elevation delta, mid-elevation burn, and high-elevation alpine tundra ranges showed the following dissimilarities:

Low-Elev. (Delta)

Cladonia-type	(40.7%)
Equisetum spp.	(22.9%)
Festuca spp.	(8.5%)

Mid-Elev. (Burn)

Cladonia-type	(87.0%)
Moss	(9.4%)
Abies lasiocarpa	(1.2%)

High-Elev. (Alpine-Tundra)

Moss	(28.8%)
Artemisia spp.	(27.5%)
Cladonia-type	(21.5%)

Cladonia lichens were important on all ranges but were more important on lower ranges. Mosses increased in importance with increased elevation while horsetails (*Equisetum* spp.) were only important on the low-elevation delta range.

Most alpine samples had a high percentage of reindeer lichens (*Cladina*, *Cladonia*) and a fairly high percentage of bryophytes (general ratio of 2:1), consistently accompanied by a moderate percentage of

graminoids *(Carex, Festuca)*. Some September samples had a high percentage of *Salix* (likely *S. arctica* and *S. nivalis)* together with some *Cladina*, moss and sedge. A few samples had significant amounts of dryad *(Dryas octopetala)* and other vascular plants.

A surprising number of low-elevation samples also contained reindeer moss. Some of this may have been brought down from alpine sites - e.g. some Medicine L. delta fecal samples had considerable *Cladina* though this species was not found on the delta. However, caribou were likely obtaining considerable caribou moss from within the coniferous forest along the Maligne Valley between Medicine and Maligne lakes. Feeding crater studies east of Maligne Lake in March showed *Cladina, Cladonia* and *Peltigera* spp. to be abundant and heavily used (Table 11). *Equisetum*, moss and graminoids were very important in the delta spring diet as they were on the low-elevation Maligne Lake range in March. One major difference between the Medicine Lake delta range and the Maligne Lake forest range was the extensive presence and use of shrubs, especially *Juniperus, Rosa, Shepherdia* and *Vaccinium* spp., on the latter range.

One Blue Lake sample contained only alpine fir. Two sets of samples (Marble Mt., Brazeau) in August had high amounts of *Salix* and fairly high amounts of *Astragalus, Carex* and *Potentilla*.

The overall forage pattern was one of few plant types, especially reindeer lichens, making up the bulk of fecal samples, and a variety of other plants occurring in trace amounts. This may be partly a reflection of food habits and partly a reflection of differential breakdown of forages consumed. We know, for example, that there can be a high percentage of forbs consumed in summer, but these are generally

not reflected in fecal sample analysis. Diet determinations from range sampling as presented in Section 4.1.2 may more accurately reflect summer caribou diet.

4.1.4.2 Rumen analysis

Results of rumen analysis from four caribou collected by the senior author in 1962 and 1963, north and east of Jasper are presented in Table 15. These samples represent winter and spring diets from subalpine and alpine-tundra zones and an early winter diet within a Canadian coniferous zone of the Foothills region. The most obvious difference among the samples was the high percentage of lichens (70%) in the sample from the coniferous foothills compared to that from the mountains (20%). Also of interest was the high percentage of graminoids in the mountain samples (40-55%) compared to the heavily forested foothils area (5%).

The foothills sample was more similar to rumen samples analysis in Norway (Gaare & Skogland 1971). The Norway study showed that in winter caribou were restricted to bare windswept ridges where a high portion of utilization was composed of lichens (especially *Cladina mitis* and *Cetraria nivalis)* and graminoids. There was little use of dwarf shrubs and moss. In late winter-spring, lichens and graminoids (especially *Carex* spp. and *Festuca ovina*) were the main forage groups, with considerable use of dwarf shrubs *(Vaccinium vitis-idaea* and *Empetrum* sp.) and rock lichens (especially *Umbilicaria* spp.). It was observed that the shift in consumption patterns between winter and late winter-spring reflected a shift in site to snowfree south exposures in late winter.

Table 15. Caribou rumen analysis from specimens collected during winter and spring, north and east of Jasper National Park, 1962 and 1963.

Area	Age & Sex	Rumen Analysis*
CONIFEROUS FOREST (Foothills: Twp. 55 - Rge 24W5) 23 Nov./63		
Oldman R. headwaters	♂ 2.5 yrs.	Lichens = 70% (*Cladonia alpestria* and *C. mitis* mostly with traces of *Stereocaulon* spp.); Mosses = trace; Graminoids = 5%; *Pinus* needles = 10-15%; *Salix* spp. = 5%; *Vaccinium vitis-idaea* and *V. uliginosum* = 5%; *Cornus canadensis* = trace.
SUBALPINE SHRUBBY MEADOW 3 Dec./62		
Rock Cr. headwaters	♀ calf	Lichens = 20% (*Cetraria nivalis* and *C. crispa* 15%, *Cladonia* 4-5%, *Peltigera* trace); mosses = 5%; Graminoids = 40-45%; *Equisetum* spp. = 15%; *Ledum groenlandicum* = 5-10%; Shrubs = 5% (*Vaccinium vitis-idaea, Betula glandulosa* & *Salix* spp.).
ALPINE-TUNDRA** 14 May/63		
Nickerson Ridge (N. of Sheep Creek & W. of Smoky R.)	♀ 0.9 yrs. ♂ 0.9 yrs.	Lichens = 20% (*Cladonia* spp. = 12%, *Cetraria nivalis* & *C. crispa* = 7%, *Stereocaulon* sp. = 1%); *Polytrichum* sp. = 5%; Graminoids = 55%; Shrubs = 20% (*Ledum groenlandicum* = 5%, *Vaccinium vitis-idaea* and *V. uliginosum* = 5%, *Salix* spp. = 5%, *Potentilla* & *Fragaria* spp. = 5%, *Saxifraga tricuspidata* = trace).

* Rumen separation screens used were 5, 10 and 20 gauge.

** Lichens and mosses identified from this site by Dr. L. Kennedy (University of Alta. Botany Dept.) were as follows:

Lichens - *Cetraria nivalis, C. pinastri, C. cucullata, Alectoria jubata, Cladonia gracilis* and *C. mitis.*

Mosses - *Rhytidium rugosum* (most common) and *Polytrichum juniperinum*

Graminoids were mainly *Calamagrostis canadensis, Carex saximontana* and *C. scirpoidea, Koeleria cristata, Agropyron latiglume, Trisetum spicatum* and *T. montanum, Poa arctica* and *Bromus marginatus.*

Scotter (1966) observed that barren-ground caribou in northern Canada used fruticose lichens of the genus *Cladonia* as the main source of winter food (> 50% total forage). *Peltigera* spp. were the second most abundant diet species. Lichens comprised 73.0, 54.8 and 52.2% of the total forage he sampled from Saskatchewan, Manitoba and the Northwest Territories, respectively. Forbs were present in trace amounts in only two samples and these consisted of Leguminosae and *Cornus canadensis*. Miller (1976) reported similar findings for the winter period on the same groups of barren-ground caribou. He also reported a shift from a predominantly lichen diet during winter to a diet of twigs, leaves and grasslike plants during June to September.

Studies of mountain caribou *(R.t. montanus)* in Wells Gray Park, (Edwards and Ritcey 1960) and in the Selkirk Mountains of British Columbia (Freddy 1974) indicated a medium-high use of arboreal lichens *(Alectoria* spp.*)* at all times of the year, particularly during the winter months when excessive snow eliminates ground foraging. No evidence of feeding craters was found during the winter in the Selkirk mountains. Miller (1976) also mentioned that arboreal lichens *(Cetraria* spp.*)* became important forage for barren-ground caribou in the taiga during periods of extremely hard snow conditions in late winter. Information on winter caribou diets in Jasper is not extensive, however feeding crater analysis at Maligne Lake indicated that caribou utilized arboreal lichens *(Alectoria glabra* and *Cetraria pinastri)* moderately during March 1973. However, *Cladina arbuscula* and *Peltigera apthosa* were the more heavily used lichen species. *Shepherdia canadensis, Rosa acicularis, Deschampsia caespitosa, Solidago multiradiata* and *Equisetum scirpoides* were heavily utilized vascular species (Table 8).

The feeding chronology of wild reindeer in southern Norway changed from 95% use of *Cladonia* heaths from December to April to 50% use of *Deschampsia*-dominated grass meadows in early spring (and late fall) and 95% use of *Salix* and herb-dominated snowbeds in early and late summer. Bogs received 45% of the midsummer use (Skogland 1972). Sulkava and Helle (1972) reported a similar foraging pattern for domesticated reindeer in Finland, but stressed the importance of aboreal lichens (*Alectoria* spp.) during late winter and early spring when the snow became very hard.

4.1.5 Range competition

There appears to be a dominance-avoidance relationship between elk and caribou, with elk taking the dominant role and displacing caribou from common range areas (Stelfox and Bindernagel 1978). There is also competition for foraging sites, and in some cases forage species, particularly during spring and summer on certain ranges. Tables 16 and 17 show range use (animal days-use/hectare) by caribou, elk and other ungulates on the Medicine Lake delta during spring (1972-74) and on the Brazeau range during late summer (1972). Caribou and elk did occupy the Medicine Lake delta concurrently during May 1972 and 1973 displaying a high degree of "interspecific tolerance" (Stelfox and Bindernagel 1978). Pellet group counts (Table 16) indicated a much greater use of the delta by caribou (77.3%) than by elk (22.2%) over the three-year period. In 1972 and 1973, the high ratio of old to fresh elk pellet groups indicated that greater use of the delta by elk occurred during fall and winter, whereas caribou frequented the area in spring as demonstrated by the greater proportion of fresh pellet groups as compared

Table 16. Range use of the Medicine Lake Delta by caribou and elk during spring periods, 1972-74.

	Caribou			Elk		
	Fresh	Old	Total	Fresh	Old	Total
			May 1972* (0.21 ha)			
No. Pellet Groups/ha	462.1	330.9	793.0	72.9	525.3	598.2
Animal-days Use/ha	35.6	25.5	61.1	5.7	40.3	46.0
% of Species Use	58.3	41.7	100.0	12.2	87.8	100.0
% of Ungulate Use	33.2	23.8	57.0	5.2	37.8	43.0
			May 1973* (0.06 ha)			
No. Pellet Groups/ha	428.2	214.2	642.4	82.3	296.5	578.8
Animal-days Use/ha	32.9	16.6	49.4	6.4	22.7	29.1
% of Species Use	66.7	33.4	100.0	21.7	78.3	100.0
% of Ungulate Use	41.9	20.9	62.9	8.1	29.0	37.1
			May 1974* (0.06 ha)			
No. Pellet Groups/ha	49.4	1581.4	1630.9	0.0	329.6	329.9
Animal-days Use/ha	3.7	121.6	124.3	0.0	25.5	25.5
% of Species Use	3.0	97.0	100.0	0.0	100.0	100.0
% of Ungulate Use	2.5	80.7	83.2	0.0	16.8	16.8
			Average for all three years (0.33 ha)			
No. Pellet Groups/ha	313.3	598.5	911.8	51.6	208.8	260.4
Animal-days Use/ha	24.0	46.0	70.0	4.0	16.1	20.1
% of Species Use	34.4	65.6	100.0	19.8	80.2	100.0
% of Ungulate Use	26.7	51.1	77.8	4.4	17.8	22.2

*Sampling plots were as follows:

1972 - 1.23 m^2 plots were taken every five paces along six transects. No. plots = 127 (0.21 ha).

1973 - 0.89 m^2 circular plots were sampled along two transects, each 300 m in length. Total = 0.06 ha.

1974 - total counts were made in ten belt transects, each 2.01 m x 30.2 m (0.06 ha.)

Table 17. Range use of the Brazeau River region by caribou and other ungulates during summer (August), 1972.

	Sample Size (ha)	Caribou				Elk				Other Ungulates			
		Pellet Groups per ha			Days-use per ha	Pellet Groups per ha			Days-use per ha	Pellet Groups per ha			Days-use per ha
		Fresh	Old	Total		Fresh	Old	Total		Fresh	Old	Total	
Valley Bottom (John-John Creek) 2286m-2316m	0.21	169.8	289.6	459.4	35.3	0.0	54.9	54.9	4.2	0.0	0.0	0.0	0.0
Valley Bottom to Summit (John-John Creek) 2316m-2438m	0.07	119.8	164.8	284.6	22.0	0.0	74.9	74.9	5.7	0.0	0.0	0.0	0.0
Along Ridge-top (Goetz Creek) 2377m	0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.5√	0.0	20.5√	1.5√
Below Ridge-top (Goetz Creek) 2225m-2255m	0.07	15.1	74.9	90.0	6.9	0.0	59.8	59.8	4.7	0.0	15.1√√	15.1√√	1.2√√
Sub-alpine Slope (Marble Mountain) 2073m-2134m	0.06	0.0	16.6	16.6	1.2	49.4	477.6	527.0	40.5	0.0	131.7√√ 65.7√	131.7√√ 65.7√	10.1√√ 4.9√
Alpland (near Goetz Creek) 2286m-2499m	0.20	5.4	65.2	70.6	5.4	0.0	10.9	10.9	0.7	10.9√	0.0	10.9√	0.7√
Krummholz (Marble Mountain) 2286m-2377m	0.20	0.0	152.5	152.5	11.6	0.0	217.7	217.7	16.8	65.2√	27.2√	92.4√	7.2√
South-facing Slope (Goetz Creek) 2286m	0.09	0.0	21.7	21.7	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Averages	0.85 ha	77.5	112.2	156.5	12.01	-	149.3	157.5	12.1	32.2√	73.4√√ 46.5√	73.4√√ 47.4√	5.7√√ 3.6√
% of Total Use					67.5				24.6				1.0√√ 18.5√

√ Sheep
√√ Mule Deer

to old. In spring 1974, there appeared to have been very little use of the delta by either species; instead the animals (especially caribou) seemed to have utilized the range during the previous fall and winter. A similar offset pattern of range utilization occurred in the Brazeau region.

Caribou showed a preference for the valley bottom to the summit region along John-John Creek from 2290 m to 2438 m whereas elk frequented the subalpine slopes and krummholz communities on Marble Mountain from 2070 m to 2377 m. Overlap occurred in almost all areas with caribou accounting for the greatest percentage of total use (67.5%). Elk accounted for 24.6% with sheep and mule deer accounting for 7.5 and 0.4%, respectively (Table 16).

Analysis of caribou and elk fecal material collected on the Medicine Lake delta in May and the Brazeau area in August indicated some direct competition for forage species (Tables 14 and 18). Both caribou and elk utilized *Carex* spp. and *Festuca* spp. to a moderate extent, but the greatest competition was for *Equisetum* spp. which made up 22.9% of caribou and 71.2% of elk fecal material from the Medicine Lake delta. *Carex, Festuca, Salix, Astragalus, Potentilla, Equisetum* and *Cladonia* species were favored forage species of caribou and elk on the Brazeau ranges with *Salix* being the most important for caribou and *Carex* for elk.

4.2 Caribou

4.2.1 Population trends: 1915-1973

Population trends for caribou and elk from 1915 to 1973 were discussed in an earlier report (Stelfox and Warden Service 1974). Caribou were generally abundant throughout the western 75% of the

Table 18. Percent relative density of forage fragements from 14 elk fecal samples, January, May and August, 1972.

Forage Species	Athabasca Valley (Jan.)				Medicine Lake (May)		Brazeau (Aug.)			
	Marmot turnoff	Portal Creek	Miette River	(3)* Ave.	Delta (3) Total	Delta (3) Ave.	Subalpine (6) Total	Subalpine (6) Ave.	Alpine-tundra (2) Total	Alpine-tundra (2) Ave.
GRAMINOIDS										
Agropyron spp.	3.08	0	5.04	4.06	0	0	0	0	0	0
Bromus spp.	6.52	1.69	0.58	2.93	0	0	3.18	1.06	0.59	0.59
Carex spp.	6.52	16.02	0.58	7.71	26.28	8.76	465.87	77.65	12.89	6.45*
Elymus spp.	0.59	0	0	0.59	0	0	0	0	0	0
Festuca spp.	31.53	34.11	29.53	31.72	50.62	16.87	7.38	1.48	15.29	7.65*
Juncus spp.	0.59	0.84	0	0.72	0	0	0.53	0.53	0	0
Poa spp.	0	0	0		0	0	0.75	0.75	0	0
Unknown grass	0	0	0		0	0	0.81	0.81	0	0
Total & Averages	48.83	52.66	35.73	45.74	76.90	25.63	478.52	28.28	28.77	14.69
LARGE SHRUBS AND TREES										
Abies lasiocarpa	37.22	32.26	61.59	43.59	0.22	0.22	4.95	1.65	84.09	42.05
Salix spp.	1.81	2.57	0	2.19	1.36	1.36	35.16	8.79	0	0
Shepherdia canadensis	12.14	12.51	2.41	9.02	2.07	2.07	2.83	1.42	1.18	1.18
Totals & Averages	51.17	47.34	63.69	54.06	3.65	3.65	42.94	11.86	85.27	43.23
FORBS AND LOW SHRUBS										
Astragalus spp.	0	0	0	0	0	0	4.74	4.74	0	0
Linnaea borealis	0	0	0	0	0	0	0.75	0.75	0	0
Potentilla spp.	0	0	0	0	0	0	6.47	6.47	0	0
Unknown Composite	0	0	0	0	0	0	0.27	0.27	0	0
Dryas spp.	0	0	0	0	0	0	0.75	0.75	0	0
Totals & Averages	0	0	0	0	0	0	12.98	12.98	0	0
LICHENS, MOSSES, CLUB-MOSSES AND HORSETAILS										
Moss	0	0	0.58	0.58	5.75	1.92	19.68	3.28	77.27	38.64
Equisetum spp.	0	0	0	0	213.7	71.23	45.88	7.65	0	0 *
Cetraria type	0	0	0	0	0	0	0	0	0.59	0.59
Cladonia type	0	0	0	0	0	0	0	0	4.37	4.37*
Peltigera apthosa	0	0	0	0	0	0	0	0	3.14	1.57
Lycopodium sp.	0	0	0	0	0	0	0	0	0.59	0.59
Total & Averages	0	0	0.58	0.58	219.45	73.15	65.56	10.93	85.96	45.76

* sample size

park from 1915 to the early 1960's. Numbers of caribou and elk in the park during three periods were estimated to be as follows (Stelfox and Warden Service 1974):

	1915-1940	1945-1960	1960-1973
Caribou	370-875	415-725	425-711
Elk	0→1075	1350→1925	1975→2375

Caribou numbers fluctuated between 360 and 875 during the period 1915 to 1960, while elk numbers increased from none in 1915, to 88 in 1920 with an introduction from Yellowstone National Park, to about 1100 in 1940, and from about 1400 in 1945 to 1900 in 1960.

In the Willow and Blue creeks area, wardens counted 200+ caribou and no elk in 1939, compared to 71 caribou and 533 elk in 1967.

In the Cavell area, wardens reported 186 caribou and 0 elk in 1961 compared to 50-75 caribou and 150-200 elk in 1969.

Between the Snaring and Miette rivers, caribou numbers declined slightly from 50-75 during 1915-1940 to 40-50 during 1961-1973, while elk numbers increased from 0-25 between the same two periods.

East and south of the Athabasca Valley, especially along the Maligne Range, caribou numbers actually increased from 110-250 during 1915-1940 to 225-275 during 1961-1973, while elk also increased from none to 325 during 1915-1940 to 475-750 during 1961-1973.

4.2.2 Correlations with coniferous forest and snowfield distributions

The authors determined the distribution of lodgepole pine and spruce-fir forests, together with summer snowfields and compared these distributions with those for caribou and elk throughout the park.

The pine forest is extensive and continuous throughout the Athabasca Valley and along the Miette (N side), Snake Indian (two-thirds

up), Moosehorn and part of the Smoky rivers. It also covers much of the southeast portion of the park along the Brazeau drainages. Spruce-fir occurs mainly as smaller forest stands in the higher valleys. The largest tracts are near Maligne Lake, west of Maligne Canyon, the Rocky River drainage, the western divide from Fortress Lake to the Miette River, and northward along the western ranges to the north end of the park.

Caribou distributions in the park are correlated with areas having a high proportion of spruce-fir forests compared to pine forests. The Rocky River drainage is the major exception and here the extreme steepness of the mountains and scarcity of alpine passes may be reasons for the absence of caribou.

A better correlation was found between caribou range and summer snowfields. There are virtually no glaciers or summer snowfields east of the caribou range, but there are many scattered throughout the entire caribou range.

Elk distributions were positively correlated with lodgepole pine forests and aspen-fringed grasslands. Such areas were most common along valley bottoms below 1650 m, especially along the Athabasca, Miette, Rocky, Fiddle, Moosehorn and Snake Indian valleys.

Figure 1 shows the summer and winter distributions of caribou and elk throughout the park. A high proportion of spruce-fir forests and summer snowfields are associated with the areas delineated as caribou range.

4.2.3 Seasonal distributions by habitat type

4.2.3.1 Warden reports and aerial surveys

Observations on a total of 1398 caribou and 16,951 elk during

LEGEND
Winter
Summer
Caribou
Elk
N
RIVER

Figure 1. Summer and winter distributions of caribou and elk in Jasper National Park, 1971–1973.

the period August 1971 to November 1973 were correlated to habitat types; only three or four supported the majority of caribou and elk (Table 19 and Figure 2).

Caribou used the Alpine-Tundra, Delta Shorelines, Barren Ridges, Snowfield and Heather-Krummholz types in the order of preference. These habitats accounted for 81.8% of caribou observations while the first two habitats supported 46% of the caribou observed. Conversely, elk used the Man-made Grasslands, Pine, Mixed Coniferous and Natural Grasslands in that order of preference. While 87.7% of the elk were observed in these four habitats, the first two types accounted for 66.3% of the elk seen. Caribou were not observed in the Avalanche Path, Deciduous-Coniferous or Poplar types. Less than 2% of the caribou were seen in each of the Burn, Pine and Man-made Grassland habitats.

Elk were not observed in the Burn or Snowfield habitats, and less than 1% of the observations were in each of the Avalanche, Heather-Krummholz and Alpine-Tundra types.

Concerning the use of various habitat types on a seasonal basis, the Delta-Shorelines type (e.g. Medicine Lake delta) was important to caribou during the months of May, June, November and December. From 48 to 78% of the monthly caribou observations were made in this type during those months. The greatest use of this habitat by elk occurred in March (5.8% of March observations).

The Shrubland type, consisting mainly of willow and dwarf birch along valley bottoms above 1525 m, was important to caribou in October (50.5%), and to elk in June and July (7.8 and 5.8%).

The four habitat types where nearly similar numbers of both caribou and elk were observed were Delta-Shorelines (269 caribou and

Table 19. Habitat preference by caribou and elk per month for the period August 1971 to November 1973 in Jasper National Park from warden monthly reports and aerial surveys.

	Sample Sizes		Percent occurrence by habitat type per month																										Year long	
			Jan*		Feb		March		April		May		June		July		Aug		Sept		Oct		Nov		Dec			
	Caribou	Elk	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	C	E	Caribou	Elk
	269	257	10.0	1.2	3.5	0	0	5.5	0	1.6	45.2	4.7	63.0	3.0	0	1.8	0	0	3.1	1.7	3.1	1.6	69.5	0.4	78.3	0.6	19.2	1.3
Delta-Shorelines (Rivers & Lakes) wet grasslands																												
Shrubland (Willow-Dwarf birch) muskeg	53	210	0	0.3	0	2	0	0.7	0	2.3	0	0.4	0	7.8	0	5.8	0.4	1.7	1.2	2.3	50.0	0.6	0	0.4	0	1.7	3.5	1.1
Grasslands (Man-made)	12	0295	0	60.6	7.0	33.0	0	10.2	0	10.2	0	17.2	0	7.4	0	0	3	0	1.5	4.4	3.1	31.4	0	53.7	0	30.5	0.9	32.0
Dry Grassland (Natural) & Meadow	57	2225	0	10.9	0	23.4	0	10.1	0	15.0	0	14.1	9.1	23.3	52.9	20.9	[illegible]	[illegible]	7.4	0.3	0	5.5	0	3.5	0	33.7	4.1	11.3
Pine	25	4939	10.0	9.2	0	22.5	1.[illegible]	49.9	0	56.5	1.[illegible]	51.3	1[illegible].2	24.3	0	58.7	0.4	29.5	3.6	51.4	3.1	45.	0	21.2	4.4	11.5	1.5	25.9
Spruce	47	456	17.6	7.4	0	2.5	3.[illegible]	0.3	0	2.0	0	[illegible]	9.1	11.3	0	0	0.5	2.5	2.5	2.6	20.0	1.1	0	0.1	0	1.2	3.4	2.5
Mixed Coniferous	41	4123	1.1	6.9	0	11.0	32.7	7.[illegible]	0	2.[illegible]	2.4	2.[illegible]	0	15.[illegible]	5.3	10.2	0	13.3	1.5	14.[illegible]	3.1	9.5	5.4	9.9	0	7.3	3.0	21.0
Poplar	0	151	0	0.5	0	1.2	0	0	0	7.4	0	0	0	[illegible]	[illegible]	0.4	[illegible]	[illegible]	[illegible]	0	0	1.0	0	0	0	0.5	0	0.9
Deciduous - Coniferous	0	316	0	2.3	0	3.4	0	6.5	0	0.7	0	3.3	0	2.1	0	1.[illegible]	[illegible]	2.1	0	1.1	0	2.[illegible]	0	0.3	0	1.3	0	1.[illegible]
Burn	20	0	10.0	0	[illegible].1	0	0	0	0	0	0	0	0	0	0	0	[illegible]	0	0	0	0	0	[illegible].1	0	0	0	1.4	0
Avalanche Path	0	12	0	0.1	0	0.[illegible]	0	0.9	0	[illegible]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1
Heather - Krummhols	134	145	26.7	0.4	0	0	0	0	0	0	3.7	0	0	0	15.[illegible]	0	[illegible].2	[illegible].7	37.4	15.3	0	0	0	0	0	0	9.6	[illegible].7
Alpine Tundra (Meadow & slopes)	374	154	14.4	0.2	[illegible].1	0	14.6	1.9	0	0	21.3	4.[illegible]	0	0.7	10.[illegible]	0	33.[illegible]	31.1	27.2	0	1[illegible].5	0	[illegible].4	0.2	0	0	20.[illegible]	[illegible].[illegible]
Barren Ridge & slope	232	305	10.0	0.1	73.3	0.2	34.[illegible]	0	0	2.[illegible]	22.[illegible]	0	[illegible]	0.4	15.[illegible]	0.4	[illegible].5	[illegible].3	23.9	[illegible].3	0	0	10.7	3.[illegible]	17.4	2.2	16.6	1.[illegible]
Snowfield	134	0	0	0	0	0	12.7	0	0	0	0	0	0	0	0	0	25.[illegible]	0	0	0	0	0	0	0	0	0	9.6	0

* C = Caribou, E = Elk

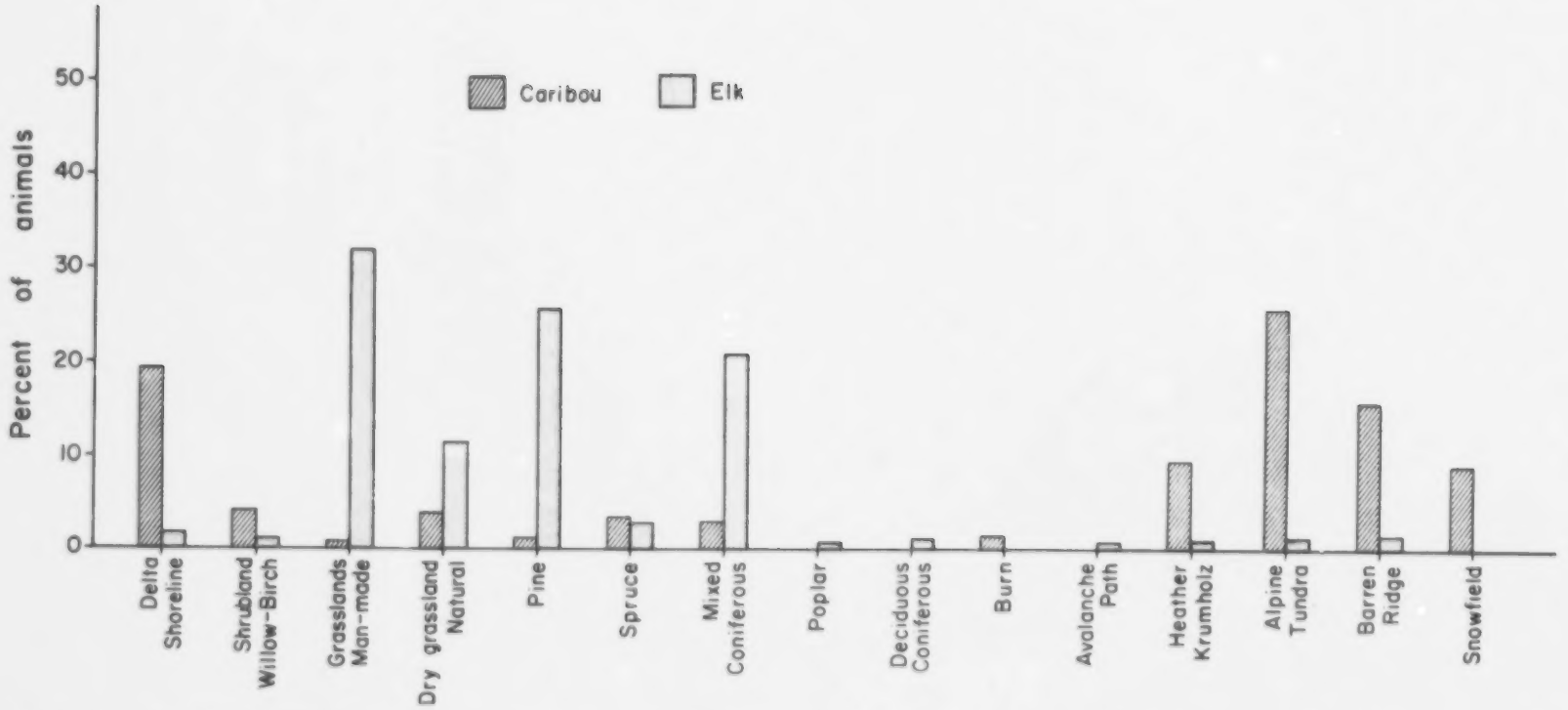

Figure 2. Habitat preference by caribou and elk for the period from August 1971 to November 1973 in Jasper National Park from monthly warden reports and aerial surveys.

257 elk), Barren Ridge and Slope (232 and 305), Alpine Tundra (374 and 154), and Heather-Krummholz (134 and 145). Three other habitat types where at least 3.0% of the caribou were seen and where at least 10.0% of the elk were seen were Natural Grasslands (57 caribou and 2,225 elk), Mixed Coniferous (41 and 4,123), and Pine (25 and 4,939). These seven habitat types were the ones which received the greatest combined use by caribou and elk.

4.2.3.2 Pellet group counts

The relative degree of use by caribou and other ungulates of nine ranges which support caribou is presented in Table 20.

The Medicine Lake delta received the heaviest use by both caribou (61 days-use/ha) and elk (56 day-use/ha) for a total of 117 days-use/ha for all ungulates. Use of the other ranges (days-use/ha) in descending order were the Bald Hills (55), Snowbowl (29), Marmot Basin (20), Campus Pass (17), Blue Lake (14), Marble Mtn. (12), Maligne Pass (4) and Mt. Clitheroe (3).

The average use by caribou of these ranges was 23 days-use/ha. Range overlap with elk occurred on the Medicine Lake delta and to a lesser extent on the Marble Mtn. ranges, while an overlap with moose occurred on the Blue Lake and to a slight degree on the Maligne Pass ranges. Rocky Mountain bighorn sheep and mule deer shared the Marble Mtn. range with caribou and elk.

The comparatively high use of spring ranges reflects the high caribou use of areas with favorable nival areas.

The Marble Mtn. range includes the area known as John-John Creek between Marble Mtn. and Jonas Pass.

Table 20. Ungulate pellet group densities on nine caribou ranges.

Range	Seasons Used by Caribou*	Pellet Groups & Days-Use ( ) Per Hectare				
		Caribou	Elk	Moose	Other	Total
Bald Hills	W ,SP	711 (55)	-	-	-	711 (55)
Medicine Lake Delta	W,SP	793 (61)	730 (56)	-	-	1523 (117)
Marmot Basin	W,SP	267 (20)	-	-	-	267 (20)
Blue Lake	SU	124 (10)	-	49 (4)	-	173 (14)
Snowbowl	SU	371 (29)	-	-	-	371 (29)
Maligne Pass	SU	50 (4)	-	2 (0.2)	-	52 (4)
Marble Mtn.	SP,SU	84 (7)	51 (4)	-	13 (1) Sheep 5 (0.4) Deer	153 (12)
Campus Pass	SU	222 (17)	-	-	-	222 (17)
Mt. Clitheroe	SU	35 (3)	-	-	-	35 (3)

*W = winter, SP = spring, SU = summer.

Table 21 compares caribou use with that of other ungulates for various Alpine-Tundra, Subalpine-Alpine Tundra, and Canadian Coniferous ranges on a monthly basis.

Tables 22 and 23 compare the use by caribou and other ungulates of Evelyn Creek, Bald Hills and Maccarib Creek ranges during spring and summer compared to winter and for six plant communities.

The "Old Burn" above Grizzly Flats (Sunwapta Valley) received moderate use by caribou (29 days-use/ha) during winter and to a lesser extent during spring, with light use by elk (2 days-use/ha) during winter.

Caribou made the greatest use of the Blue Lake range during winter but also used that range extensively during spring and summer. Moose used that range mainly during spring and summer (75%) but also used it during winter (25%).

Table 21 shows that caribou spent an average of 54.8 days-use/ha on Canadian Coniferous ranges, predominantly on Delta Shorelines in spring, compared to 16.2 days-use/ha on Subalpine-Alpine Tundra ranges and 15.6 days-use/ha on Alpine-Tundra ranges. The high use of Canadian Coniferous ranges is believed to be biased on the high side as three of the four use values were from the Medicine Lake delta which is small in size and not typical of the Canadian Coniferous zone. Use of the Blue Lake (Snake Indian) range (9.4 days-use/ha) is believed more typical of caribou use of low-elevation ranges.

For high-elevation ranges at Evelyn Creek, Bald Hills and Maccarib Creek, caribou made the greatest use of Alpine Meadow communities, especially the *Anemone occidentalis-Carex*-grass-*Artemisa norvegica* community, followed next by the *Carex* and herb-moss communities in that order.

Table 21. Range use (days-use/ha) by caribou and other ungulates of various ranges, 1972-74.

Localities	Sample size (ha)	CARIBOU Pellet Groups per ha Fresh*	CARIBOU Pellet Groups per ha Old**	CARIBOU Pellet Groups per ha Total	CARIBOU Days-use*** per ha	ELK Pellet Groups per ha Fresh*	ELK Pellet Groups per ha Old**	ELK Pellet Groups per ha Total	ELK Days-use*** per ha	OTHER UNGULATES Pellet Groups per ha Fresh*	OTHER UNGULATES Pellet Groups per ha Old**	OTHER UNGULATES Pellet Groups per ha Total	OTHER UNGULATES Days-use*** per ha
Alpine-Tundra (2134 m - 2286 m)													
Marmot Basin (Aug. 1972)	0.17	0.0	265.6	265.6	20.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Campus Pass (Aug. 1972)	0.20	20.0	204.6	224.6	17.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mt. Clitheroe (Aug. 1972)	0.42	16.6	18.8	35.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maccarib Creek (Aug. 1973)	1.26	65.7	98.1	163.8	12.6	0.0	1.5	1.5	0.3	0.0	0.7√	0.7√	<0.2√
											1.5√√	1.5√√	0.2√√
Brazeau (Aug. 1972)	0.36	118.1	203.1	321.2	24.7	0.0	54.9	54.9	4.2	0.0	2.7√√√	2.7√√√	<0.2√√√
(John-John Creek)													
Average		55.1	158.04	202.1	15.6	0.0	28.2	28.2	2.3				
Sub-Alpine-Alpine-Tundra (1981 m - 2286 m)													
Bald Hills (May 1972)	0.38	-	-	710.7	54.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bald Hills (Sept. 1973)	0.45	51.6	6.7	58.3	4.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Snowbowl (July 1972)	0.04	74.1	296.5	370.6	28.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Evelyn Creek (August 1973)	3.40	37.1	20.5	57.6	4.4	0.3	1.7	2.0	0.3	0.5√√	2.1√√	3.2√√	0.2√√
										0.0√	0.2√	0.2√	<0.2√
Maligne Pass (July 1972)	0.62	11.4	38.8	50.2	4.0	0.0	0.0	0.0	0.0	-	-	1.7√√	0.1√√
Brazeau (August 1972)	0.06	0.0	16.6	16.6	1.2	49.4	477.6	527.0	40.5	0.0√	131.7√	131.7√	10.1√
(John-John Creek)										0.0√√√	65.7√√√	65.7√√√	4.9√√√
Average		43.6	75.8	210.7	16.2	24.9	239.7	264.5	20.4				
Canadian Coniferous Zone (1372 m - 1829 m)													
(a) Valley Bottom (1433m-1829m)													
Snake Indian (July 1972)													
(Blue Lake)	0.08	48.9	73.6	122.6	9.4	0.0	0.0	0.0	0.0	36.8√√	12.4√√	49.2√√	3.7√√
Medicine Lake (May 1972)	0.21	462.1	330.9	792.9	61.0	72.9	525.3	598.2	46.0	0.0	0.0	0.0	0.0
Medicine Lake (May 1973)	0.06	428.2	214.2	642.4	49.4	82.3	296.5	378.8	29.2	0.0	0.0	0.0	0.0
Medicine Lake (May 1974)	0.06	49.4	1581.4	1630.8	125.5	0.0	329.6	329.6	25.5	0.0	0.0	0.0	0.0
(b) East Slope (1829m)													
"Old Burn" (June 1973)													
(above Grizzly Flats)	0.04	114.1	274.5	374.3	28.9	0.0	25.0	25.0	2.0	0.0	0.0	0.0	0.0
Average		220.5	494.9	712.6	54.8	77.6	294.1	371.7	25.7				
Averages overall	7.81ha	106.4	242.9	349.3	28.9	51.3	187.3	238.6	16.1	0.7√√	1.5√√	2.2√√	<0.2√√
										0.0√	1.2√	1.2√	<0.2√
										0.0√√√	0.5√√√	0.5√√√	<0.2√√√
% of Total Use					83.3				14.7				2.7√√
													0.5√
													0.5√√√

* Includes recent spring and summer pellets
** Includes winter pellets and old summer pellets
*** Calculated from total number of pellet groups per ha, on the basis of an assumed defecation rate of thirteen groups per day per animal
√ Mule deer
√√ Moose
√√√ Sheep

Table 22. Range use (days-use/ha) by caribou of various plant communities, August 1973.

Ecosystem /or Plant Community	EVELYN CREEK Elev. (m)	Sample size (ha)	Pellet Groups per ha: Spring and Summer	Winter	Total	Days-use/ ha	BALD HILLS Elev. (m)	Sample size (ha)	Pellet Groups per ha: Spring and Summer	Winter	Total	Days-use/ ha	MACCARIB CREEK Elev. (m)	Sample size (m)	Pellet Groups per ha: Spring and Summer	Winter	Total	Days-use/ ha
Fellfield Tundra	2195-2316	0.64	25.0	12.6	37.6	3.0	2225	0.17	12.1	18.0	30.1	2.2	2316-2377	0.15	33.4	0.0	33.4	2.47
Mountain Heather (all sites)	2073-2255	1.70	23.0	20.8	43.8	3.5	2195	0.13	15.6	0.0	15.6	1.2	2103-2316	0.66	78.3	141.6	219.9	16.8
Above Krummholz													2255-2316	0.14	21.3	14.1	35.4	2.7
In upper Krummholz													2195-2255	0.17	94.1	58.8	152.9	11.9
In lower Krummholz													2134-2195	0.25	117.4	222.9	340.3	26.2
In open Engelmann spruce forest													2103-2134	0.11	38.1	256.5	294.6	22.7
Alpine Meadow (all sites)	2073-2286	0.49	135.9	53.6	189.5	14.6	2164	0.15	126.8	0.0	126.8	9.6	2103-2134	0.06	131.7	263.7	395.4	30.4
Anemone occidentalis-Carex-grass-*Artemisia norvegica* community	2164-2195	0.07	247.1	150.7	397.8	30.6							2103-2134	0.06	131.7	263.7	395.4	30.4
Carex community	2073-2286	0.17	206.8	51.6	258.4	20.0	2164	0.05	0.0	0.0	0.0	0.0						
Herb-moss "	2134-2225	0.23	52.9	26.4	79.3	6.2	2164	0.10	187.8	0.0	187.8	14.3						
Willow-moss "	2103	0.01	0.0	0.0	0.0	0.0												
Mountain Heather-Alpine Meadow													2164	0.12	98.8	41.3	140.1	10.9
Sub-Alpine Meadow																		
Wet sedge comm.	2042-2103	0.19	15.8	0.0	15.8	1.2												
Willow-moss "													2012	0.14	14.1	7.2	21.3	1.7
Engelmann Spruce Forest	1981-2134	0.35	3.0	0.0	3.0	0.3							2012-2103	0.13	0.0	47.9	47.9	3.7
Averages		3.40 ha	40.5	29.0	57.9	4.5		0.45 ha	85.6	-	90.1	6.8		1.26 ha	69.7	117.1	168.1	12.9

Table 23. Range use (days-use/ha) by ungulates other than caribou

Ecosystem and/or Plant community	Elev. (m)	Sample size (ha)	EVELYN CREEK Pellet Groups per ha Spring & Summer	Winter	Tot
Fellfield Tundra	2195-2316	0.64	0.0	0.0	0.
Mountain Heather (all sites)	2073-2255	1.74	0.0	1.2√	1
				3.0√√	3
Above Krummholz					
In upper Krummholz					
In lower Krummholz					
In open Engelmann spruce forest					
Alpine Meadow (all sites)	2073-2286	0.49	4.0√	14.3√	18
			2.0√√	2.0√√	4.
			0.0√√√	2.0Ω	2.
Anemone accidentalis-Carex-grass-*Artemesia norvegica* community	2164-2195	0.07	0.0	0.0	0.
Carex community	2073-2286	0.17	5.7√√	0.0	5.
Herb-moss community	2134-2225	0.23	0.0	17.5√	17.
				4.4√√	4.
				4.4Ω	4.
Willow-moss community	2103	0.01	164.8	247.1√	411.
Mountain Heather-Alpine Meadow					
Sub-alpine Meadow					
Wet sedge community	2042-2103	0.19	0.0	0.0	0.
Willow-moss "					
Engelmann Spruce Forest	1981-2134	0.35	0.0	0.0	0.
Averages		3.40 ha	0.5√	2.7√	3.
			0.3√√	1.7√√	2.
			0.0Ω	0.2Ω	0.

√Moose. √√ Elk √√√Deer. ΩMule deer

mmunities, August 1973.

BALD HILLS						MACCARIB CREEK					
Elev. (m)	Sample size (m)	Pellet Groups per ha			Days-use per ha	Elev. (m)	Sample size (ha)	Pellet Groups per ha			Days-use per ha
		Spring & Summer	Winter	Total				Spring & Summer	Winter	Total	
2225	0.17	0.0	0.0	0.0	0.0	2316-2377	0.15	0.0	0.0	0.0	0.0
2195	0.13	0.0	0.0	0.0	0.0	2103-2316	0.66	0.0	0.0	0.0	0.0
						2256-2316	0.14	0.0	0.0	0.0	0.0
						2195-2256	0.17	0.0	0.0	0.0	0.0
						2134-2195	0.25	0.0	4.0✓	4.0✓	0.2✓
						2103-2134	0.11	0.0	19.0✓✓	19.0✓✓	1.5✓✓
									9.4Ω	9.4Ω	9.4Ω
						2103-2134	0.06	0.0	0.0	0.0	0.0
2164	0.05	0.0	0.0	0.0	0.0						
2164	0.10	0.0	0.0	0.0	0.0						
						2104	0.12	0.0	8.2✓	8.2✓	0.7✓
						2012	0.14	0.0	7.2✓	7.2✓	0.5✓
						2012-2103	0.13	0.0	0.0	0.0	0.0
	0.45 ha	0.0	0.0	0.0	0.0		1.26 ha	0.0	2.5✓	2.5✓	0.2✓
									1.5✓✓	1.5✓✓	0.2✓✓
									0.7Ω	0.7Ω	<0.2Ω

For the Mountain Heather communities, caribou preferred the Lower Krummholz, Open Engelmann Spruce, Upper Krummholz, and above Krummholz areas in that decreasing order of preference (Table 22).

The Mountain Heather-Alpine Meadow community was used more (10.9 days-use/ha) than either the Engelmann Spruce (below the Mountain Heather communities) or the Subalpine Meadow communities (3.7 and 1.7 days-use/ha).

On these high-elevation ranges, elk use was greatest on the Mountain Heather community in an Open Engelmann Spruce (1.5 days-use/ha) and next on the *Carex* community in an Alpine Meadow area (0.5 days-use/ha). Moose concentrated on the Willow-Moss community (31.6 days-use/ha) with a small amount of use on Herb-Moss (1.2 days-use/ha), Alpine Meadow (0.7 days-use/ha), Willow-Moss (0.5 days-use/ha), and Lower Krummholz (0.2 days-use/ha) communities. Deer use was confined to the Open Engelmann Spruce and Herb-Moss communities (9.4 and 0.2 days-use/ha).

4.2.4. Seasonal distribution correlated to snow depth and wind

Caribou and elk distributions by month are correlated to both snow depths and wind in Table 24 and Figure 3 (from Stelfox and Warden Service 1974).

Caribou were observed where snow depths ranged up to 130 cm during the January-March period whereas elk were not observed on ranges with snow depths exceeding 30 cm.

The average snow depth where caribou were observed during the period September through May was 67.1 cm compared to 7.9 cm for elk. By totalling average monthly snow depths for caribou and for

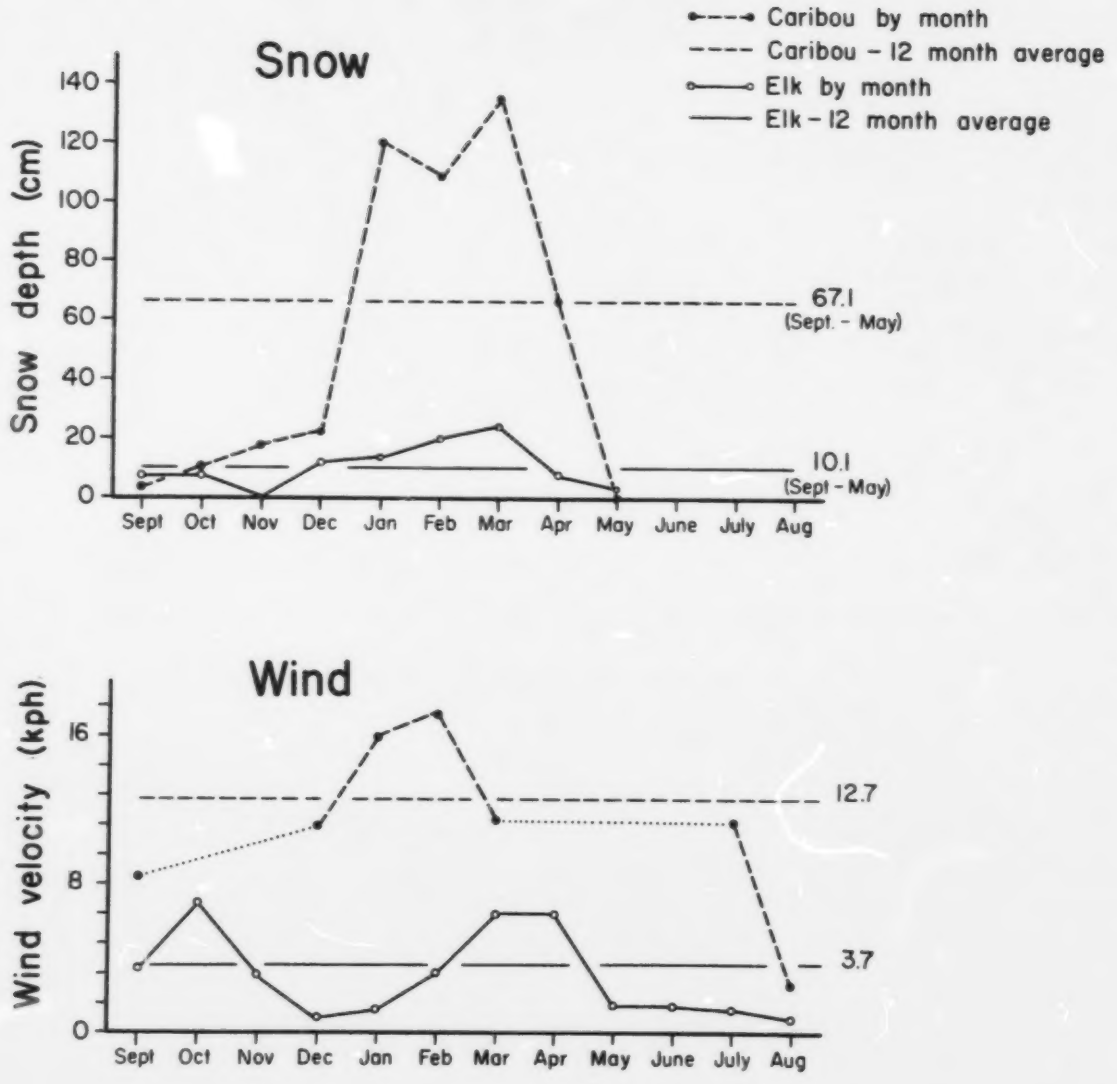

Figure 3. The distribution of caribou and elk in relation to snow depth and wind velocity, 1971 to 1973.

Table 24. Snow depths, cloud cover, and wind velocities on caribou and elk ranges in Jasper National Park, February 1972 to January 1973.

Date	Snow Depths (cm)				% Cloud Cover		Wind Velocities (kph)			
	Elk		Caribou		Elk	Caribou	Elk		Caribou	
	Range	Mean	Range	Mean	Mean	Mean	Range	Mean	Range	Mean
February, 1972	0-120	20.4	40-170	108.5	60.9	75.0	0-19	3.5	3-37	17.2
March	0-120	25.1	128-145	136.5	57.5	61.2	0-24	6.6	10-16	11.7
April	0-63	7.8			63.3	25.0	0-16	6.6		
May	0-30	3.8	0-15	1.2	50.7	32.3	0-16	1.6		
June					53.6	100.0	0-16	1.6		
July					51.2	52.9	0-24	1.4	0-40	11.7
August					38.3	23.4	0-16	0.8	0-24	2.9
September	1-7	5.0	0-15	3.8	65.1	52.1	0-16	4.0	0-24	8.5
October	1-15	6.9			48.1	25.0	0-40	6.9		
November	0-2	.8	2-31	17.6	66.5	37.5	0-32	3.5	0	0
December	0-20	12.3	2.5-60	22.2	50.0	93.8	0-8	1.0	0-16	11.3
January 1973	2-55	13.7	120	120.0	63.8	-	0-6	1.6	0.32	16.0

elk in Table 24, values of 409.[illegible] cm and 95.8 cm, respectively, were obtained. These values indicated during the winter of 1971-72 caribou were coping with 4.3 times as much snow as were elk.

The average annual wind velocity where caribou were observed was 12.7 kilometres per hour (kph) compared to 3.7 kph where elk were observed. Totalling the average monthly wind velocities provided values of 79.5 kph for caribou and 39.3 kph for elk. These values indicated that caribou were exposed to twice as much wind annually as were elk. The stronger winds on caribou ranges are probably beneficial in baring forage on some ridges and slopes on deep-snow winter ranges at high elevations. This action may be vital in the winter survival of caribou on Alpine-Tundra ranges. Strong winds at high elevations are also beneficial to caribou in compacting snow to the point where caribou are able to move across the snow without penetrating to depths which would impede their movement. The major reasons why caribou are able to utilize deep snow winter ranges which elk cannot are probably:

1. the foot load (vertical foot pressure on the ground or snow surface) is only 140 gm/cm^2 for caribou, compared to about 700 gm/cm^2 for elk (Telfer and Kelsall 1971). While walking over snow, caribou exert only 20% as much weight on the snow surface as do elk and thus penetrate only about one-fifth as far into the snow.
2. the large hoof area of the caribou compared to that of the elk makes it better adapted to pawing through deep snow to reach herbaceous vegetation.

4.2.5 Seasonal distribution by elevation and exposure

4.2.5.1 Distribution by elevation

Table 25 shows the average monthly distributions of caribou and elk by elevation zones (Stelfox and Warden Service 1974). It shows that monthly caribou distributions averaged from 1460 to 2290 m for all months. Elk, however, ranged mainly between 1040 and 1555 m with the highest average elevations reached during June and October.

For the months of July and August the two species overlapped above 1525 m, whereas in September they overlapped in the zones between 1220 and 2135 m. For February and March there was considerable overlap in the 1220 to 1525 m zone while during April and May they overlapped between 1220 and 1835 m.

The only overlaps which occurred below 1219 m were during September and to a lesser extent August and October.

4.2.5.2 Distribution by exposure (aspect)

Table 26 (from Stelfox and Warden Service 1974) compares monthly distributions of caribou and elk on each of the eight exposures. On a yearlong basis, caribou made the greatest use of the SW, S and NW exposures, whereas elk preferred the W, S, SE and E aspects in that order of importance.

During the winter season (January through March) caribou were found mainly on the NW and NE exposures, whereas elk were mainly on the W and S-facing exposures. During the spring, caribou preferred the N slopes while elk were found mainly on the SE, W and E slopes. During the summer, caribou were spread over all exposures with most observed on the S, SE and N exposures while elk preferred the W, E and S, in that order.

Table 25. Distributions of caribou and elk throughout Jasper National Park by elevational zones, August 1971 - November 1973.

Month	Number or %	--- Numbers and Percent of Monthly Observations at Each Elevation Zone ------ 1000-1220m		1220-1525m		1525-1825m		1825-2135m		2135-2440m		2440-2745m	
		Car.	Elk	Car.	Elk	Car.	Elk	Car.	Elk	Car.	Elk	Car.	Elk
January	No.	0	2496	0	178	9	88	0	16	12	11	0	0
	%	0	89.5	0	6.4	42.9	3.2	0	0.6	57.1	0.4	0	0
February	No.	0	195	9	48	0	29	18	4	48	0	0	0
	%	0	70.6	12.0	17.4	0	10.5	24.0	1.5	64.0	0	0	0
March	No.	0	600	18	137	1	104	0	21	21	0	0	0
	%	0	69.6	45.0	15.9	2.5	12.1	0	2.4	52.5	0	0	0
April	No.	-	1002	-	0	-	203	-	0	-	0	0	0
	%	-	83.2	-	0	-	16.8	-	0	-	0	0	0
May	No.	0	653	73	234	3	81	3	0	21	0	0	0
	%	0	67.5	73.0	24.2	3.0	8.4	3.0	0	21.0	0	0	0
June	No.	0	304	9	200	2	68	11	10	0	0	0	0
	%	0	52.2	40.9	34.4	9.1	11.7	50.0	1.7	0	0	0	0
July	No.	0	78	0	8	0	58	60	17	56	15	12	0
	%	0	44.3	0	4.6	0	33.0	46.9	9.7	43.8	8.5	9.4	0
August	No.	0	105	2	45	3	20	37	57	259	27	2	0
	%	0	41.3	0.7	17.7	1.0	7.9	12.2	22.4	85.5	10.6	0.7	0
September	No.	8	249	0	235	8	123	31	102	0	9	0	0
	%	17.0	34.7	0	32.7	17.0	17.1	66.0	13.2	0	1.2	0	0
October	No.	2	1687	24	436	50	117	4	24	16	0	0	0
	%	2.1	74.5	25.0	19.3	52.1	5.2	4.2	1.1	16.7	0	0	0
November	No.	0	2938	128	346	11	180	10	33	16	0	8	0
	%	0	84.0	74.0	9.9	6.4	5.1	5.8	1.0	9.3	0	4.6	0
December	No.	0	2372	72	162	4	51	20	1	12	0	0	0
	%	0	91.7	66.7	6.2	3.7	2.0	18.5	0.1	11.1	0	0	0
Yearlong	No.	10	12679	335	2029	91	1122	194	285	461	62	22	0
	%	0.9	78.4	30.1	12.5	8.2	6.9	17.4	1.8	41.4	0.4	2.0	0

Table 26. Numbers and percentages of caribou* and elk* observed on each exposure.

	No. & %	NORTH C	NORTH E	N E C	N E E	EAST C	EAST E	S E C	S E E	SOUTH C	SOUTH E	S W C	S W E	WEST C	WEST E	N W C	N W E
								WINTER									
January	No.	0	84	12	27	9	65	0	46	0	31	0	4	0	141	0	57
	%	0	18.5	57.1	5.9	42.9	14.3	0	10.1	0	6.8	0	0.9	0	31.0	0	12.5
February	No.	0	5	1	21	5	7	0	2	6	3	0	12	6	26	48	5
	%	0	6.2	1.5	25.0	7.6	8.3	0	2.4	9.1	3.6	0	14.3	9.1	32.1	72.7	6.2
March	No.	5	14	7	0	0	2	0	0	5	34	16	3	0	37	0	0
	%	15.2	15.6	21.2	0	0	2.2	0	0	15.2	37.8	48.5	3.3	0	41.1	0	0
								SPRING									
April	No.	-	0	-	0	-	21	-	30	-	0	-	3	-	59	-	42
	%	-	0	-	0	-	13.6	-	19.4	-	0	-	1.9	-	38.1	-	27.1
May	No.	20	0	0	2	0	0	0	79	0	26	1	0	0	17	3	0
	%	83.3	0	0	1.6	0	0	0	63.7	0	21.0	4.2	0	0	13.7	12.5	0
June	No.	0	0	1	3	0	32	0	14	2	10	0	2	2	45	0	2
	%	0	0	20.0	2.8	0	29.6	0	13.0	40.0	9.3	0	1.9	40.0	41.7	0	1.9
								SUMMER									
July	No.	3	3	12	0	1	54	18	8	1	9	7	0	0	54	3	16
	%	6.7	2.1	26.7	0	2.2	37.5	40.0	5.6	2.2	6.3	15.6	0	0	37.5	6.7	11.1
August	No.	17	2	8	21	14	21	5	11	86	47	4	25	9	17	0	3
	%	11.9	1.4	5.6	14.3	9.8	14.3	3.5	7.5	60.1	32.0	2.8	17.0	6.3	11.6	0	2.0
September	No.	8	49	4	26	0	71	2	0	12	48	9	12	0	82	4	26
	%	20.5	15.6	10.3	8.3	0	22.6	5.1	0	30.8	15.3	23.1	3.8	0	26.1	10.3	8.3
								FALL									
October	No.	0	30	0	42	1	17	0	58	1	72	84	18	0	29	0	18
	%	0	10.6	0	14.8	1.2	6.0	0	20.4	1.2	25.4	97.7	6.3	0	10.2	0	6.3
November	No.	0	19	0	42	12	0	4	76	5	21	0	3	4	23	4	147
	%	0	5.7	0	12.7	41.4	0	13.8	23.0	17.2	6.3	0	0.9	13.8	7.0	13.8	44.4
December	No.	4	21	0	87	0	72	28	40	0	156	0	20	0	219	16	32
	%	8.3	3.5	0	14.4	0	11.9	58.3	6.6	0	25.8	0	3.3	0	36.2	33.3	5.3
								YEARLONG									
Yearlong	No.	57	227	45	271	42	362	57	364	118	457	121	102	21	749	78	348
	%	10.6	7.9	8.3	9.4	7.8	12.6	10.6	12.6	21.9	15.9	22.4	3.5	3.9	26.0	14.5	12.1

* Total observations of 539 caribou and 2880 elk.

During the autumn, caribou occurred mainly on the SW, SE and NW exposures while elk were found mainly on the W, NW and S exposures.

4.2.6 Seasonal distribution and forage preferences

There was obvious selectivity of plant species by caribou at all times of year. Generally, in communities frequented by ungulates, plant species that were most abundant had a greater chance of being selected. The discriminating tendency of caribou was especially evident in summer when a great variety and abundance of palatable food was available. The animals seemed to focus on certain species, with shifts in preference through the summer.

In May and early June, caribou were often observed on the delta at the south end of Medicine Lake. Both dominants, *Equisetum variegatum* and *Poa palustris*, received extensive ungulate use (Westworth 1972). In 1973, graminoids were utilized more heavily (McFarlane 1973a, 1973b), but in 1974 *Equisetum* received much heavier use (Keith 1974).

In late spring, caribou frequented snowfree alpine ridges and slopes (Westworth 1972). Here the dominant vegetation was used, especially *Dryas octopetala;* also other dwarf shrubs such as *Cassiope tetragona* and *Empetrum nigrum*. Locally much *Abies lasiocarpa* krummholz was browsed as was the moss *Rhacomitrium lanuginosum* and its lichen associate *Cetraria nivalis*. There was light sporadic use of forbs and graminoids and little use of other cryptogams.

Through June there was a general shift from upland tundra vegetation, where the herbaceous and shrubby vegetation was maturing, to mesic, recently snow-free heath tundra and forb meadows above and within the forest-tundra zone. A similar shift was noted in other areas, Gaare and Skogland (1971) found that in June,fewer lichens were

used and a higher proportion of vascular plants eaten, especially young leaves of shrubs whereas herbs and succulent grasses were preferred in July. Caribou in Jasper Park probably shift from lichens to shrubs such as *Salix arctica* that are leafing out during this period.

Some caribou were found in subalpine and montane habitats in June. Three Habitat Types were involved:

1. Delta-Shorelines;
2. Subalpine *Picea-Abies* forest: shrubs and lichens especially *Peltigera apthosa* were taken, as they were in late winter;
3. Shrub meadows, where the animals fed on tall shrubs *(Salix* spp., *Betula glandulosa)* and on graminoids and lichens.

Through July there was heavy utilization of heaths especially *Cassiope mertensiana* and *Phyllodoce* spp. Also used were other dwarf shrubs: *Empetrum nigrum, Dryas octopetala, Cassiope tetragona, Vaccinium scoparium* and *Salix nivalis.* Some graminoids were taken, especially sedges such as *Carex scirpoidea.* Some forbs were taken, mainly later in the month. There was variable use of both mosses and lichens (especially *Cladina mitis*) from none to heavy.

In the Maligne Pass area, caribou pasturing along a hummock, subalpine valley bottom fed only in the hollows where most of the forbs were found. They did not use the dwarf shrub *Luetkea pectinata* despite its very high cover; and they showed an uncharacteristic disinterest in *Salix arctica,* a species that seems to be used extensively through the rest of the year. Nor was there any utilization of mosses or lichens though both were abundant and were taken at other times of the year.

In August, the greatest utilization was of the dwarf shrubs *Vaccinium scoparium* and *Salix arctica*. A wide variety of other plants was also taken. Dwarf shrubs seemed to be used most heavily, e.g. *Cassiope mertensiana, Phyllodoce* spp., *Dryas octopetala, Empetrum nigrum*. There was generally light use of graminoids and forbs, consisting mainly of those with the highest percent cover. There was moderate use of *Caltha leptosepala* and *Trollius laxus*, and light use of other forbs, at the end of August.

Utilization of cryptogams was virtually nil in summer, especially August. The reasons for this may be: (1) their relative scarcity in most of the Heather-Krummholz communities; (2) their relative inconspicuousness, e.g. hidden under the dwarf shrubs in heath-dominated communities; (3) the abundance of bulkier and probably more palatable food especially forbs and deciduous shrub foliage and young shoots.

When autumn snowfalls were light, caribou fed on dwarf shrubs and forbs until October. Then (or earlier depending on snowdepth) there was a shift back to high utilization of lichens and mat-forming shrubs such as *Dryas octopetala* and *Salix nivalis*. In Norway, lichens, expecially *Cladonia* spp. and *Cladina mitis*, were again the main component of the diet by October (Gaare and Skogland 1971).

The Shrubland Habitat Type *(Salix, Betula glandulosa)* was important in October, constituting 51% of that month's sightings (Stelfox and Warden Service 1974).

In November and December, the Delta-Shoreline HT seemed most important. From November on, there was probably some utilization of arboreal lichens in mature spruce-fir forest. *Usnea* and *Alectoria*

are common genera in Jasper and may be very abundant in unburned, mesic forests at 1525-2135 m.

In January and February, caribou in the alpine-tundra sought areas with thin or no snowcover. Here they fed on lichens, especially *Cetraria, Cladonia* and *Alectoria* spp., mosses, some *Dryas octopetala/integrifolia* and any other dwarf shrubs that were exposed. There was low use of forbs and graminoids (possibly because these were scarce in comparison with comparable sites in northern Europe). The pattern of utilization was similar to that reported in Norway (Gaare and Skogland 1971): a high proportion of lichens, especially *Cetraria* and *Cladonia* spp. plus *Cladina mitis* in addition to some use of graminoids. There was little use of dwarf shrubs, and extremely little use of mosses.

Caribou in the subalpine forest, as in alpine-tundra, made use of whatever was available (except mosses). Westworth (1973) investigated feeding craters at Maligne Lake and found heavy utilization of the leafy terrestrial lichen *Peltigera apthosa* (an ubiquitous species through the subalpine forests), and some use of reindeer lichens (*Cladina* spp.) and other lichens of the *Cladonia* group. There was considerable use of shrubs, generally in proportion to their abundance: *Vaccinium vitis-idaea, Ledum groenlandicum, Linnaea borealis, Arctostaphylos uva-ursi.* There was some use of graminoids, especially the common *Elymus innovatus* and *Carex concinna.* Forbs were brown and showed little use. Although moss cover was high, it seemed very little used (Table 8).

In summary, food preferences varied markedly throughout the year. This is consistent with other studies (Skogland 1972).

4.2.7 Foraging in relation to floral phenology

During the spring to fall period, caribou habitat and forage species preferences were strongly influenced by floral phenology. In general, the animals seemed to continually seek pastures with lush new plant growth, especially where herbaceous species were in flower.

Beginning in late April and early May, caribou moved down to lake deltas and alluvial flood plains where snow melt was early and cold-weather graminoids and forbs were beginning new growth. *Equisetum*, *Carex*, *Festuca* and *Poa* spp. were major forage species. At that time considerable quantities of *Cladonia* lichens and mosses were taken. Subalpine fir also formed an important part of the May diet as new stem and needle growth was occurring.

During July, caribou in the Maligne Pass area concentrated on *Caltha leptosepala* and *Pedicularis arctica* that were succulent and in the early flower stage in the mesic depressions between hummocks (Table 9). During 19-22 July 1974 at the headwaters of Jeffery Creek, caribou pastured extensively in a saturated basin supporting a *Carex albo-nigra*, moss-*Caltha-Phyllodoce* community. The area was dotted with hummocks supporting mostly *Phyllodoce empetriformis*, *Carex* spp., *Salix arctica* and *Pedicularis arctica*. The low, wet areas between the hummocks supported *Caltha leptosepola*, *Anemone occidentalis*, *Carex* spp., moss, *Ranunculus*, *Kalmia* and *Poa* spp. The caribou were selecting *Caltha leptosepola* almost exclusively and it was in the early flower stage (Table 27). Elsewhere, *Anemone occidentalis* had just finished flowering and was no longer consumed although it had been eagerly sought in early July when in flower. *Carex albo-nigra* had a few flower heads and formed 8% of the diet.

Table 27. Diet composition for caribou in the Snowbowl area (2300 m), 22 July 1974.

Species	Relative Abundance	Floral Phenology	Percent* Diet
Caltha leptosepala	moderate	flowering	79
Trollius albiflorus	moderate	late flowering	2
Petasites sp.	light	flower stalks 2-6"	4
Vaccinium spp.	light	prior to flowering	4
Carex albo-nigra	moderate	some flower heads	8
Poa sp.	light	2-3" high, no flower stalks	1
Agropyron sp.	light	2-3" high, no flower stalks	1
Salix arctica	moderate	1-2% high, not in flower	1

* based on 100 utilization hits.

Caribou pasturing in a Krummholz-Fellfield Tundra habitat in the Campus Pass area on 29 August 1972 fed almost exclusively on flowers and to a lesser extent on leaves of succulent plant species shown in Table 28.

Table 28. Diet preference and portions of plants used by caribou at Campus Pass, 29 August 1972.

	Total Plants Grazed		Portions of Plants Eaten		
Species	No.	%	Flower	Leaf	Stem
Trollius albiflorus	23	50.0	23		
Caltha leptosepala	14	30.4	14		
Arnica sp.	6	13.4	6		24
Anemone sp.	2	4.3		2	
Salix arctica	1	2.1		1	
Totals	46	100.2	43	3	24

It appears then that the diet of caribou varies seasonally with a definite switch from aboreal lichens in winter to plants in early stages of growth in spring. Edwards and Ritcey (1960) in Wells Gray Park, B.C., and Freddy (1974) in the Selkirk Mountains of Northern Idaho cite evidence of caribou seeking green forage as soon as it became available. Freddy (1974) also observed caribou eating bark from the apical tip of small subalpine fir in early spring.

5.0 SUMMARY AND CONCLUSIONS

The Warden Service in Jasper National Park became concerned about an apparent decline in caribou numbers in the late 1960's that coincided with a marked increase in the number of hikers and elk on caribou ranges. Three studies were initiated by the Canadian Wildlife Service in cooperation with the Jasper Warden Service to:

1. determine the abundance and distribution of caribou and elk;
2. study caribou behavior in relation to human-elk-wolf influences;
3. study the range ecology of caribou.

This report presents the results of range ecology studies during the period 1971-1974. Detailed studies were conducted along the Maligne Range from Shovel Pass to the Bald Hills and Maligne Pass, in the John-John Creek area between Poboktan Pass and Marble Mountain, and the Medicine Lake delta. Less detailed studies were conducted on the Cavell Alplands, the old burn above Grizzly Flats, the Subalpine-Alpine Tundra ranges of Marmot Mountain, Tonquin Valley, Maccarib and Blue Creeks and the coniferous forest east of Maligne Lake.

Jasper lies within the East Slope of the Rockies and has a modified continental climate of fairly cold winters and warm summers.

The mean annual temperature at Jasper townsite is 2.5°C, mean January temperature is -14.5°C and the July mean is 15.2°C. The mean annual precipitation is 37.5 cm. About 75% of this falls as snow in the subalpine zone.

Soils represent 5 orders: Podzol, Brunisol, Regosol, Gleysol and Chernozem. Forest soils are typically Brunisols with Brunisols and Podsols common for mature alpine soils. Gleysols predominate in areas of impeded drainage while some low-elevation grasslands have Chernozems.

There are three major ecological zones-montane (up to 1400 m), subalpine (1400-2000 m) and alpine above 2000 m. Timberline is at 1900-2100 m on cool aspects and 2000-2200 m on warm aspects.

Jasper has over 600 vascular plant species in about 250 genera and 67 families. There are also about 250 bryophytes and 200 lichens.

Fifteen wild ungulate habitat types were designated, namely: Delta Shoreline and Wet Grassland, Lodgepole Pine, Spruce-Fir, Heather-Krummholz, Alpine-Tundra, Barren Ridgetop, Shrubland, Man-made Grassland, Natural Grassland, Mixed Coniferous, Poplar, Deciduous-Coniferous, Recent Burns, Avalanche Paths, Snowfields.

For each plant community studied, information was gathered on plant community composition; plant density, canopy coverage, utilization, phenology and biomass; tree and shrub density and coverage; soil profile descriptions and topography; ungulate abundance and caribou diet.

Between 1350 and 1650 AD there was a major glacial advance that reached its maximum in the early 18th century, then remained stationary until recession began in the late 18th century. There was a readvance in the early 19th century followed by a general retreat since the mid-1800's.

Associated with the warming trend since 1850 was an increase in the number of forest fires, many created by humans. There was a marked decrease in the area of mature spruce-fir forests and an increase in lodgepole pine forests, grassland and scrub ranges which increased the park's carrying capacity for elk, bighorn sheep, mule deer and moose. The decline in mature spruce-fir forests and warmer conditions were believed to have reduced the carrying capacity for caribou.

Five important caribou ranges above 1830 m and their corresponding plant biomass productions (dry weight) were: Engelmann Spruce - Subalpine Fir (1188 kg/ha), Mountain Heather (1105 kg/ha), Fellfield Tundra (978 kg/ha), Alpine and Forest Tundra Meadow (478 kg/ha) and Boulder Rubble Field (no biomass data). The low-elevation Delta Shoreline and Wet Grassland, so important as spring pasture for caribou, produced 637 kg/ha plant biomass.

Species and/or genera identified on these ranges included 19 trees and shrubs, 32 graminoids, 8 horsetails and club-mosses, 106 forbs and low shrubs, 15 mosses and 45 lichens, for a total of 225 different plants. The 20 most preferred spring-fall forage species, in decreasing order of preference, were: *Bromus marginatus, Carex albo-nigra, Pedicularis arctica, Peltigera apthosa, Cladina arbuscula, Equisetum scirpoides, Valeriana sitchensis, Lomatium* sp., *Linnaea borealis, Carex concinna, Potentilla nivea, Senecio resedifolius, Phyllodoce glanduliflora, Rhacomitrium lanuginosum, Dryas octopetala, Caltha leptosepala, Polytrichum piliferum, Arctostaphylos uva-ursi, Trollius albiflorus* and *Abies lasiocarpa.*

The 10 plants which contributed the most to caribou summer diet were: *Rhacomitrium lanuginosum, Equisetum scirpoides, Pleurozium*

schreberi, Pedicularis arctica, Dryas integrifolia, Polytrichum piliferum, Betula glandulosa, Dryas octopetala, Senecio resedifolius and *Peltigera apthosa.*

During the period winter-spring, lichens and graminoids especially *Carex* spp. and *Festuca ovina* were the main forage groups, with considerable use of dwarf shrubs (*Vaccinium vitis-idaea* and *Empetrum* sp.) and rock lichens (especially *Umbilicaria* spp.).

During late winter, in low-elevation coniferous forests, caribou utilized *Alectoria glabra* and *Cetraria pinastri* lichens moderately in addition to *Cladina arbuscula* and *Peltigera apthosa* heavily. Vascular species used heavily at that time included *Shepherdia canadensis, Rosa acicularis, Deschampsia caespitosa, Solidago multiradiata* and *Equisetum scirpoides.*

There was a dominance-avoidance relationship between elk and caribou, with elk taking the dominant role and displacing caribou from common ranges. There was also competition for foraging sites, and in some cases forage species, particularly during spring and summer.

Analysis of caribou and elk fecal material showed that both species competed heavily for *Equisetum* spp. and moderately for *Carex* and *Festuca* spp. on the Medicine Lake delta in May. On high-elevation Brazeau ranges, *Carex, Festuca, Salix, Astragalus, Potentilla, Equisetum* and *Cladonia* species were favored forage species of both caribou and elk during August. *Salix* spp. were most preferred by caribou compared to *Carex* spp. for elk at that time.

Caribou numbers in the park fluctuated between 360 and 875 during the period 1915-1960, while elk numbers increased from none in 1915, to 88 in 1920 with an introduction from Yellowstone National Park, to about

1100 in 1940, and 1900 in 1960. In the Willow-Blue creeks area, wardens counted 200+ caribou and no elk in 1939, compared to 71 caribou and 533 elk in 1967. Similar counts in the Cavell area were 186 caribou and 0 elk in 1961 compared to 50-75 caribou and 150-200 elk in 1969.

Caribou distributions were correlated with areas having a high proportion of spruce-fir compared to pine forests and alpine-tundra ranges with broad valleys and traversable passes. A better correlation was found between caribou range and summer snowfields with virtually no glaciers or summer snowfields east of the caribou range but many scattered snowfields plus glaciers throughout the caribou range.

Five habitat types accounted for 81.8% of the caribou observations: Alpine-Tundra, Delta Shoreline and Wet Grassland, Barren Ridges, Snowfield, and Heather-Krummholz. The four habitat types that accounted for 87.7% of the elk observed were Man-made Grasslands, Pine, Mixed Coniferous and Natural Grasslands. Caribou were not observed in the Avalanche Path, Deciduous-Coniferous or Poplar types and less than 2% of the caribou were seen in each of the Burn, Pine and Man-made Grassland habitats.

The Delta-Shoreline habitat was important to caribou during May, June, November and December, whereas the Shrubland was important in October.

Four habitat types where nearly similar numbers of caribou and elk were observed were Delta Shoreline , Barren Ridge and Slope, Alpine Tundra and Heather-Krummholz. Three types where at least 3.0% of the caribou and 10.0% of the elk were seen were Natural Grasslands, Mixed Coniferous, and Pine. These seven habitat types are the areas of greatest potential caribou-elk conflict.

The average snow depth where caribou wintered (September-May) was 67.1 cm compared to 7.9 cm where elk wintered.

Average annual wind velocities where caribou were observed was 12.7 kph compared to 3.7 kph where elk were observed.

On a yearlong basis, caribou made greatest use of the SW, S and NW exposures, compared to W, S, SE and E exposures for elk.

Marked seasonal distribution shifts occurred, with caribou concentrating on lake deltas in May and June to feed on new growth of *Equisetum variegatum* and *Poa palustris*. In late winter and spring they also used snowfree alpine ridges and slopes foraging on *Dryas*, *Cassiope*, *Empetrum*, *Rhacomitrium* and *Cetraria* spp. plus *Abies lasiocarpa*.

Through June they gradually moved from maturing upland tundra vegetation to mesic, recently snowfree heath tundra and forb meadows above and within the forest-tundra zone. During July, there was heavy utilization of heaths, and dwarf shrubs plus a variety of forbs, especially those in the early flowering stage. In August, the greatest use was made of dwarf shrubs such as *Vaccinium scoparium* and *Salix arctica* while use of graminoids and forbs decreased. Utilization of cryptogams was virtually nil during summer.

When autumn snowfalls were light, caribou fed on dwarf shrubs and forbs until October. Then there was a shift back to high utilization of lichens and mat-forming shrubs such as *Dryas octopetala* and *Salix nivalis*. In November and December caribou again moved onto the lake deltas and also used arboreal lichens in mature spruce-fir forests.

In January and February, caribou on the alpine-tundra ranges sought areas of thin or no snowcover to feed on lichens and dwarf shrubs. At that time in low-elevation mature coniferous forests they

foraged on whatever was available. They utilized *Peltigera apthosa* heavily, and used *Cladina* and *Cladonia* lichens, *Vaccinium vitis-idaea*, *Ledum groenlandicum*, *Linnaea borealis* and *Arctostaphylos uva-ursi* moderately.

6.0 RECOMMENDATIONS

Winter fecal samples of caribou should be collected for the period November-April and analysed to improve the information on winter diet in various habitat types.

Information on forage conflicts between caribou and elk should be collected whenever available.

A more detailed study on the importance of mature coniferous forests and summer snowfields to caribou should be conducted.

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APPENDIX I

Checklists of Plants

From Caribou Ranges

Table 1. Lichens from caribou ranges in Jasper National Park, 1973

Collected by J.G. Stelfox, Canadian Wildlife Service, Edmonton, Alberta
Identified by R.R. Ireland, National Museum of Canada, Ottawa, Ontario

Name	Number of Specimens
Alectoria fremontii Tuck.	2
Alectoria lanestris (Ach.) Gyeln.	2
Alectoria lanestris	
Alectoria oregana Tuck. ex. Nyl. s. str.	1
Alectoria cfr. *lanestris*	2
A. sarmentosa (Ach.) Ach. subsp. *sarmetosa*	4
A. sarmentosa subsp. *vexillifera* (Nyl.) D. Hawksw.	1
Cetraria islandica (L.) ach.	3
Cetraria laevigata Rass.	1
Cetraria nivalis (L.) Ach.	2
Cetraria pinastri (Scop.) S. Gray	2
Cladina arbuscula (Wallr.) Hale and W. Culb.	5
Cladonia bellidiflora (Ach.) Schaer.	1
Cladina mitis (Sandst.) Hale and W. Culb.	3
Cladonia bacillaris (Ach.) Nyl.	1
Cladonia cariosa (Ach.) Spreng.	1
Cladonia carneola (Fr.) Fr.	
Cladonia deformis (L.) Hoffm. and C. spp.	1
Cladonia coccifera (L.) Willd.	3
Cladonia deformis (L.) Hoffm.	2
Cladonia digitata (L.) Hoffm.	
Cladonia cenotea (Ach.) Schaer.	1
Cladonia fimbriata (L.) Fr.	2
Cladonia gonecha (Ach.) Asah.	7
Cladonia gracilis (L.) Willd.	5
Cladonia gracilis var. *dilata* (Hoffm.) Vain.	2
Cladonia gracilis elongata (Jacq.) Fr.	6
Cladonia multiformis Merr.	3
Cladonia phyllophora Hoffm.	2
Cladonia pyxidata (L.) Hoffm.	1
Cladonia subulata (L.) Wigg.	1
Cladonia uncialis (L.) Wigg.	1
Cladonia verticillata (Hoffm.) Schaer.	1
Cladonia sp.	2
Cornicularia aculeata (Schreb.) Ach.	1
Dactylina arctica (Hook.) Nyl.	2
Hypogymnia enteromorpha auct. non. Ach.	2
Icmadophila ericetorum (L.) Zahlbr.	
Lecidea granulosa (Ehrh.) Ach.	1
Lecidea granulosa	3
Letharia vulpina (L.) Hue.	2
Nephroma arcticum (L.) Torss.	2

Name	Number of Specimens
Nephroma expallidum Nyl.	4
Parmeliopsis hyperopta (Ach.) Arn.	1
Peltigera aphthosa (L.) Willd.	1
Peltigera canina (L.) Willd. var. *canina*	1
Peltigera leucophlebia (Nyl.) Gyeln.	4
Peltigera malacea (Ach.) Funck	1
Peltigera scabrosa Th. Fr.	1
Pertusaria dactylina (Ach.) Nyl.	1
Rhizocarpon geographicum (L.) DC.	1
Stereocaulon alpinum Laur.	1
Stereocaulon cfr. *paschale* (L.) Hoffm.	1
Stereocaulon cfr. *paschale* (L.) Hoffm.	2
Stereocaulon tomentosum Fr.	2
Thamnolia subuliformis (Ehrh.) W. Culb.	2
Usnea sorediifera (Arn.) Lynge	2
Crust (fertile)	1
Cladonia chlorophaea (Florke ex. Somm.) Spreng	1
Cladonia cfr. *chlorophaea*	1
Cladonia cfr. *Lecidea granulosa*	1
Peltigera horizontalis-polydactyla	1
Rhizocarpon spaerosporum Ras.	1
Solorina crocea (L.) Ach.	1
Sterile crust	1
Total	119

Determined by P.Y. Wong
29 November 1973.

Table 2 Checklist of plants associated with caribou range in Jasper National Park

VASCULAR PLANTS

LYCOPODIALES	
Lycopodium alpinum L	alpine clubmoss
L. annotinum .	stiff clubmoss, bristly groundpine
Selaginella densa Rydb.	little clubmoss, spikemoss
EQUISETALES	
Equisetum arvense L.	common horsetail, field horsetail
E. scirpoides Michx.	sedgelike horsetail
E. variegatum Schleich.	variegated horsetail
CONIFERALES	
Abies lasiocarpa (Hook.) Nutt.	alpine fir
Juniperus communis L.	common juniper, ground juniper
Picea engelmanni Parry ex Engelm.	Engelmann spruce
Pinus contorta Dougl. ex Loud. var. *latifolia* Engelm.	lodgepole pine
ANGIOSPERMS - MONOCOTS	
Carex albonigra Mack.	
C. concinna R. Br.	
C. nardina Fries	
C. nigricans C.A. Mey.	
C. spectabilis Dewey	black alpine sedge
Deschampsia atropurpurea (Wahlenb.) Scheele	mountain hairgrass
D. cespitosa (L.) Beauv.	tufted hairgrass
Elymus innovatus Beal	hairy wild rye
Festuca brachyphylla Schultes	alpine fescue
Hierochloe alpina (Sw.) R.&S.	alpine sweetgrass
Juncus drummondii E. Meyer	
J. nodosus L.	jointed rush
Luzula parviflora (Ehrh.) Desv.	millet woodrush
L. spicata (L.) DC.	spike woodrush
Phleum alpinum L.	mountain timothy
Poa cusickii Vasey	skyline bluegrass
P. grayana (P. arctica)	arctic bluegrass
P. lettermanni Vasey	
P. palustris L.	fowl bluegrass
Trisetum spicatum (L.) Richter	spike trisetum

Veratrum viride Ait. var. *eschscholtzii* (R.&S.) Breitung	false hellebore
Zigadenus elegans Pursh	white camas

ANGIOSPERMS - DICOTS

Achillea millefolium L.	common yarrow
Anemone multifida Poir.	cut-leaved anemone
A. occidentalis Wats.	western anemone, chalice-flower
A. parviflora Michx.	northern anemone, few-flowered an.
Antennaria lanata (Hook) Greene	woolly pussytoes
Arctostaphylos uva-ursi (L.) Spreng.	common bearberry
Arnica diversifolia Greene	
A. latifolia Bong.	broad-leaved *arnica*
A. mollis Hook.	hairy *arnica*
Artemisia norvegica Fries	
Betula glandulosa Michx.	dwarf birch, bog birch
Campanula lasiocarpa Cham.	alpine bluebell
Cassiope mertensiana (Bong.) D. Don	white mountain heather
C. tetragona (L.) D. Don	white mountain heather
Castilleja occidentalis Torr.	western paint-brush
C. rhexifolia Rydb.	broad-leaved paintbrush
Cerastium beeringianum Cham. & Schlecht.	
Claytonia lanceolata Pursh	western spring beauty
Dryas octopetala L. ssp. *hookeriana* (Juz.) Hulten	white dryad, white mt. avens
Empetrum nigrum L.	crowberry
Epilobium alpinum L.	alpine willowherb
Erigeron aureus Greene	golden fleabane
E. humilis Graham	
E. peregrinus (Pursh) Greene	showy fleabane, aster fleabane
Fragaria virginiana Duchesne	wild strawberry
Kalmia polifolia Wang. var. *microphylla* (Hook.) Rehd.	mountain laurel
Ledum groenlandicum Oeder	Labrador tea
Linnaea borealis L.	twin-flower
Luetkea pectinata (Pursh) Kunze	partridgefoot, Alaska *spiraea*
Myosotis sylvatica Hoffm. var. *alpestris* (F.W. Schmidt) Koch	alpine forget-me-not
Oxytropis podocarpa A. Gray	
Parnassia fimbriata Konig.	fringed grass-of-Parnassus
Pedicularis bracteosa Benth.	bracted lousewort, Indian warrior
P. arctica R. Br.	alpine lousewort
P. groenlandica Retz.	elephant-head
Petasites frigidus (L.) Fries	arctic coltsfoot
Phyllodoce empetriformis (Sw.) D. Don	red heather

P. gladuliflora (Hook.) Coville	yellow heather
Polygonum viviparum L.	alpine bistort
Potentilla diversifolia Lehm.	smooth-leaved cinquefoil
P. uniflora Ledeb.	singleflower cinquefoil
Pyrola secunda L.	one-sided wintergreen, sidebells w.
Ranunculus eschscholtzii Schlecht.	snow buttercup
Rosa acicularis Lindl.	prickly rose
Salix arctica Pall.	arctic willow
S. barrattiana Hook.	
S. nivalis Hook.	snow willow
Saxifraga bronchialis L.	common saxifrage, spotted saxifrage
S. occidentalis Wats.	meadow saxifrage
Sedum lanceolatum Torr.	stonecrope
Senecio triangularis Hook.	arrowhead ragwort, arrowleaf groundsel
Shepherdia canadensis (L.) Nutt.	buffaloberry, soapberry
Sibbaldia procumbens L.	
Wilene acaulis L.	
Solidago multiradiata Ait.	alpine goldenrod
Trollius laxus Salisb.	globe-flower
Valeriana dioica L. *(V. septentrionalis)*	
V. Sitchensis Bong.	mountain valerian
Vaccinium scoparium Leiberg	grouseberry
V. vitis-idaea L.	bog cranberry, rock cranberry
Veronica wormskjoldii Roem. & Schult.	alpine speedwell

BRYOPHYTES

Aulacomnium palustre (Hedw.) Schwaegr.
Barbilophozia hatcheri (Evans) Loeske
Brachythecium sp.
Dicranum scoparium Hedw. D. sp.
Hylocomium splendens (Hedw.) B.S.G.
Pleurozium schreberri (Brid.) Mitt.
Polytrichastrum sp.
Polytrichum juniperinum Hedw.
P. piliferum Hedw. P. sp.
Ptilium crista-castrensis (Hedw.) De Not.
Rhacomitrium lanuginosum (Hedw.) Brid. R. sp.

LICHENS

Alectoria glabra Mot. A. sp.
Cetraria cucullata (Bell.) Ach.
C. islandica (L.) Ach.
C. nivalis (L.) Ach.
C. pinastri (Scop.) S. Gray
C. tilesii Ach.
Cladina arbuscula
C. mitis (Sandst.) Hale & W. Culb.
C. rangiferina Wigg.
Cladonia cornuta (L.) Hoffm.

C. cenotea (Ach.) Schaer.
C. chlorophaea (Flörke ex Somm.) Spreng.
C. ecmocyna (Ach.) Nyl.
C. fimbriata (L.) Fr.
C. gracilis (Hoffm.) Schaer.
C. pyxidata (L.) Hoffm.
C. uncialis (L.) Wigg.
C. verticillata (Hoffm.) Schaer.
Dactylina arctica (Hook.) Nyl.
Letharia vulpina (L.) Hue
Nephroma expallidum (Nyl.) Nyl.
Parmeliopsis ambigua (Wulf.) Nyl.
Peltigera aphthosa (L.) Willd.
Rhizocarpon geographicum (L.) DC.
R. sphaerosporum
Solorina crocea
Stereocaulon alpinum Laur.
Thamnolia subuliformis (Ehrh.) W. Culb.
Umbilicaria proboscidea (L.) Schrad.
U. sp.
Usnea sp.

Table 3 Checklist of plants on mountain caribou ranges, Jasper National Park, by John G. Stelfox, 1974.

TREES AND SHRUBS

Abies lasiocarpa
Arctostaphylos uva-ursi
Betula glandulosa
Betula pumila
Cassiope mertensiana
Cassiope tetragona
Dryas drummondii
Dryas hookeriana
Dryas integrifolia
Dryas octopetala
Empetrum nigrum
Juniperus communis
Juniperus horizontalis
Juniperus scopulorum
Menziesia glabella
Phyllodoce empetriformis
Phyllodoce glanduliflora
Picea engelmannii
Pinus albicaulis
Pinus contorta
Pinus flexilix
Potentilla concinna
Potentilla diversifolia
Potentilla fruticosa
Potentilla nivea
Rosa acicularis
Salix arctica
Salix barrattiana
Salix glauca
Salix nivalis
Salix vestila
Shepherdia candensis
Vaccinium scoparium
Vaccinium uliginosum
Vaccinium vitis-idaea

GRASSES AND GRASS-LIKE PLANTS

Agropyron latiglume
Agropyron trachycaulum
Agrostis stolonifera
Agrostis variabilis
Bromus inermis
Bromus marginatus
Bromus pumpellianus
Calamagrostis montanensis
Calamagrostis purpurascens
Carex albo-nigra
Carex concinna
Carex nardina
Carex nigricans
Carex raymondii
Carex scirpoidea
Carex spectabilis
Danthonia intermedia
Deschampsia caespitosa
Elymus innovatus
Festuca brachyphyila
Festuca ovina
Kobresia bellardii
Phleum alpinum
Poa alpina
Poa arctica
Poa cusickii
Poa rupicola
Scirpus caespitosus
Trisetum spicatum

HORSETAILS AND CLUB-MOSSES

Equisetum arvense
Equisetum scirpoides
Equisetum variegatum
Lycopodium alpinum
Lycopodium annotinum
Lycopodium selago

Table 5. Plant canopy cover data, Stand #5 (Alpine & Forest Tundra Meadow).

Plant Species	Cover		Frequency (%)	Utilization	
	%	Class Number		Actual	Classification
TREES AND SHRUBS					
Picea engelmannii	.04	1	2.7	0	none
Abies lasiocarpa	0	1	0	0	none
Salix arctica	8.06	5	70.0	18 stems	moderate
S. nivalis	0	1	0	0	none
FORBS					
Cassiope tetragona	12.60	5	39.1	0	none
Vaccinium scoparium	9.71	5	84.6	20%	heavy
Valeriana eeptentrionalis	6.64	5	43.6	4 stems	light
Artemisia norvegica	5.01	5	53.6	5 stems	light
Anemone occidentalis	5.30	5	52.7	6 stems	light
A. multifida	4.08	4	39.1	0	light
Phyllodoce glanduliflora	4.74	4	29.1	0	none
P. empetriformis	2.73	4	29.1	0	none
Arnica mollis	2.69	4	48.2	1 stem	light
Antennaria lanata	1.97	4	54.6	1 leaf	light
Senecio triangularis	1.81	4	20.9	2 stems	light
Pedicularis bracteosa	0.30	2	12.7	1 stem	light
Parnassia fimbriata	0.59	3	7.3	0	none
Veronica alpina	0.40	2	28.2	1 flower	light
Lycopodium alpinum	0.12	1	4.6	0	none
Potentilla diversifolia	0.06	1	7.3	0	none
Erigeron perigrinus	0.04	1	2.7	0	none
Arnica latifolia	0.09	1	5.5	0	none
Polygonum viviparum	0.04	1	5.4	0	none
Castilleja occidentalis	<0.01	1	0.9	0	none
C. rhexifolia	0	1	0	0	none
Campanula lasiocarpa	<0.01	1	0.9	0	none
Trollius laxus (= T. albiflorus)	0.10	1	9.1	0	none
Veratrum viride (= V. eschscholtzii)	0	1	0	0	none
Myosotis alpestris	0	1	0	0	none
Saxifraga cf. *nivalis*	<0.01	1	.9	0	none
Erigeron humilis	0	1	0	0	none
Solidago multiradiata	0	1	0	0	none
Silene acaulis	0	1	0	0	none
Anemone parviflora	0.02	1	0	0	none
GRAMINOIDS					
Carex spectabilis	3.50	4	22.7	0	none
C. nigricans	3.04	4	50.0	0	none
Juncus drummondii	1.04	4	16.7	37-57 stems	moderate
Poa arctica	0.35	2	22.7	0	none
P. cusickii	0.32	2	9.1	0	none
Phleum alpinum	0.14	1	4.6	0	none
Luzula parviflora	0.06	1	7.3	0	none
Trisetum spicatum	< .01	1	0.9	0	none
Festuca brachyphylla	< .01	1	0.9	0	none
Deschampsia atropurpurea	0	1	0	0	none
MOSSES					
Aulacomnium sp.	14.0	5	50.9	0	none
Brachythecium sp.	0.18	1	0.9	0	none
Polytrichum sp.	0.06	1	4.6	0	none
LICHENS					
Cetraria islandica	0.08	1	7.3	0	none
Peltigera apthosa	0.06	1	4.6	0	none
Peltigera sp. (small)	0.03	1	3.6	0	none
Cladonia cenotea	0.04	1	5.4	0	none
C. rangiferina	<0.01	1	1.8	0	none
C. gracilis/Nephroma expallidum	0	1	0	0	none
Cladonia chlorophaea	0.02	1	.9	0	none

FORBS

Achillae millefolium
Allium schoenoprasum
Anemone occidentalis
Anemone parviflora
Antennaria alpina
Antennaria lanata
Antennaria pulcherrima
Arenaria obtusiloba
Arnica gracilis
Arnica mollis
Artemisia norvegica
Aster sibiricus
Astragalus alpinus
Caltha leptosepala
Castilleja rhexifolia
Cerastium beeringianum
Claytonia lanceolata
Cornus canadensis
Crepis nana
Draba aurea
Draba lanceolata
Epilobium alpinum
Epilobium latifolium
Erigeron aureus
Fragaria virginiana
Centiana glauca
Gentiana prostrata
Gentianella crinata
Heuchera cylindrica
Juncus drummondii
Juncus nodosus
Kalmia polifolia
Ledum groenlandicum
Linnaea borealis
Lomatium sp.
Luetkea pectinata
Luzula parviflora
Myosotis alpestris
Oxyria digyna
Oxytropis podocarpa
Parnassia palustris
Pedicularis arctica
Pedicularis bracteosa
Pedicularis groenlandica
Petasites sp.
Phacelia sericea
Polemonium viscosum
Polygonum vivparum
Pyrola asarifolia
Pyrola secunda
Ranunculus eschscholtzll
Saussurea densa
Saxifraga bronchialis
Sedum stenopetalum
Selaginella densa
Senecio resedifolius
Senecio triangularis
Sibbaldia procumbens
Silene acaulis
Solidago multiradiata
Townsendia sp.
Trifolium repens
Trollius albiflorus
Valeriana septentrionalis
Valeriana sitchensis
Zygadenus elegans

MOSSES

Aulacomnium palustre
Barbilophozia sp.
Dicranum sp.
Hylocomium sp.
Lucobryum glaucum
Pleurozium schreberi
Polytrichadelphus lanuginosum
Polytrichum juniperinum
Polytrichum piliferum
Ptilium crista-castrensis
Rhacomitrium canescens
Rhacomitrium lanuginosum
Sphagnum sp.

LICHENS

Alectoria divergens
Alectoria fremontii
Alectoria glabra
Alectoria vexillifera
Cetraria cucullata
Cladonia rangiferina
Cladonia uncialis
Cladonia verticillata
Cornicularia aculeata
Dactyllina arctica

Community Type: Engelmann Spruce - Subalpine Fir

Stand # 6 Date: 13 August Elevation: 2000 m

Exposure: NW Drainage: Good Slope: 2-5%

Topography: Mountain slope

Physiognomy:

Veget. Stratum	Tree	Shrub	Herbaceous	Ground
Cover (%)	65	1	70	3-4
Height (cm)	100-1200	33	15-20	0.5
Dominant spp.	*Abies lasiocarpa*	*Salix barrattiana*	*Cassiope tetragona*, *Phyllodoce* sp., *Artemisia norvegica*	*Aulacomnium* sp.

Successional Status: Possible succession to climax *Picea engelmannii* or *Pinus contorta* as found at lower elevations but presently dominated (≈ 64% of trees in stand) by *Abies lasiocarpa* (90 to 150 years old, max. ht. = 12 m and DBH = 12 cm). An old burn was evident and the *P. engelmannii* present (≈ 35%) was generally old (240 years). Some *P. contarta* (1% of trees in stand), age = 50 to 55 years, ht = 6-8 m, DBH = 22 cm.

Biomass of Vegetation (Dry wt. in gm.)

Forbs: 221.1 (range = 136.4 to 301.4)

Mosses and Lichens: (Lichens 1%) 253.4 (range = 31.0 - 654.1)

Graminoids: trace

Arboreal Lichens: 0.2 gm/tree. Mainly a few large, old spruce that have lichens.

Cetraria islandica
Cetraria nivalis
Cetraria pinastri
Cladina arbuscula
Cladonia carneola
Cladonia cenotea
Cladonia chlorophaea
Cladonia coniocraea
Cladonia cornuta
Cladonia fimbriata
Cladonia gracilis
Cladonia mitis
Cladonia pleurota
Cladonia pyxidata
Haematomma lapponicum
Letharia vulpina
Nephroma arcticum
Parmeliopsis ambigua
Peltigera spp.
Peltigera apthosa
Pertusaria dactylina
Physcia sp.
Ramalina sp.
Stereocaulon alpinum
Stereocaulon paschale
Thamnolia subuliformis
Thamnolia vermicularis
Usnea spp.

APPENDIX II

Vegetational Analysis of Evelyn Creek Headwaters, 2-15 August 1973

Table 1 Canopy cover data, Stand #1 (Mountain Heather)

Plant Species	Cover		Frequency (%)	Utilization	
	%	Class Number		Actual	Classification
TREES AND SHRUBS					
Salix arctica	0.26	2	9	unstated	light
Abies lasiocarpa	0	1	0	0	none
FORBS					
Cassiope tetragona	62.80	8	99	unstated	light
Phyllodoce glanduliflora	8.42	5	33	unstated	light
P. empetriformis	3.80	4	15	0	none
Antennaria lanata	2.50	4	67	0	none
Luetkea pectinata	2.06	4	51	0	none
Vaccinium scoparium	1.28	4	38	0	none
Lycopodium sp. (small)	0.70	3	4	0	none
Erigeron peregrinus	0.52	3	20	0	none
Sibbaldia procumbens	0.18	1	11	0	none
Claytonia lanceolata	0.18	1	20	0	none
Anemone occidentalis	0.16	1	8	0	none
Veronica alpina	0.14	1	9	0	none
Erigeron aureus	0.09	1	8	0	none
Castilleja occidentalis	0.02	1	3	0	none
GRAMINOIDS					
Carex nigricans	1.02	4	52	0	none
Luzula spicata	1.00	3	21	0	none
Juncus drummondii	0.03	1	9	0	none
MOSSES					
Barbilophozia sp. (mostly) + *Aulacomnium* sp.	7.93	5	41	0	none
Polytrichum sp.	0.38	2	35	0	none
LICHENS					
Peltigera sp. (orange edge)/ *Peltigera apthosa*	0.84	3	21	0	none
Ground lichens (including *Stereocaulon alpinum*)	0.78	3	18	0	none
Cladonia spp. (*C. rangiferina, C. uncialis, C. chlorophaea*)	0.51	3	11	0	none
Cetraria cuculata	0.33	2	17	0	none

Community Type: Mountain Heather (*Cassiope tetragona* - *Phyllodoce* sp.)

Stand #1 Date: 3 August Elevation: 2270 m

Exposure: NE Drainage: Good Slope: 10-15%

Topography: Mountain slope with solifluction lobes

Physiognomy:

Veget. Statum	Tree	Shrub	Herbaceous	Ground
Cover (%)	1	0	70	8
Height (cm)	30	-	6	0.5
Dominant spp.	*Abies lasiocarpa*	-	*Cassiope tetragona*	Mosses (*Dicranum* spp.)

Successional Status: Climax

Biomass of Vegetation (Dry wt. in gm):

Forbs: 441.6 (range = 433.3 to 450.0)

Graminoids, Mosses & Lichens: traces

Arboreal Lichens: none

Soil: Brunisolic with apparent material of residual shale

Horizon	Depth (cm)	Roots	Texture	Consistency	Organic Matter	Color
A	6	Abundant	V. fine sand	Loose	V. high	Brownish
B	41	Plentiful	Clay	Friable	Medium	Brownish
C	41+	Very few	Finely crushed	V. firm	V. low	Brownish

Animal Activity:

Caribou - sitings, tracks, pellet groups

Mule Deer - sightings, tracks, pellet groups

Ground squirrels - burrows

Ptarmigan - pellets

5 old caribou and 2 ptarmigan pellet groups per acre (0.4 ha).

Community Type: Boulder Rubble Field (accumulated fine microhabitat)

Stand #2 Date: 4 August Elevation: 2160 m

Exposure: N Drainage: Good Slope: 6-9%

Topography: Mountain slope

Physiognomy:

Veget. Stratum	Tree	Shrub	Herbaceous	Ground
Cover (%)	0	26	20	10
Height (cm)	-	5	5	1
Dominant spp.	-	*Salix* spp.	*Dryas hookeriana*	*Rhacomitrium* spp.

Successional Status: possibly to Subalpine fir and ultimately to Engelmann spruce. No biomass or soil data obtained.

Animal Activity:

Caribou - bull grazing area, 2 days previous; 2 old pellet groups.

Ground squirrels - sightings.

Table 2. Canopy cover data, Stand #2 (Boulder Rubble Field)

Plant Species	Cover %	Cover Class Number	Frequency (%)	Utilization Actual	Utilization Classification
TREES AND SHRUBS					
Salix arctica	26.50	7	100	3/36 plants	moderate
Abies lasiocarpa	0	1	0	0	none
FORBS					
Dryas hookeriana	16.00	6	100	0	none
Pedicularis groenlandica	4.37	4	100	0	none
Silene acaulis	0	1	0	0	none
MOSSES					
Rhacomitrium sp.	10.25	5	80	0	none
Polytrichum piliferum	.05	1	20	0	none
Hylocomium splendens	0.15	1	20	0	none

LICHENS

Stereocaulon alpinum	2.00	4	20	0	none
Peltigera apthosa	1.95	4	80	0	none
Cetraria islandica	0.83	3	60	0	none
Cladonia uncialis	0.75	3	40	0	none
Cladonia ranaifernia	0.75	3	40	0	none
Cladonia chlorophaea	0.30	2	40	0	none
Dactylina arctica	0.05	1	20	0	none
Rhizocarpon sphaerosporum	0	1	0	0	none

Community Type: Alpine and Forest Tundra Meadow (*Carex nigricans* - snowbed)

Stand #3 Date: 9 August Elevation: 2355 m

Exposure: E Drainage: Good Slope: 16-29%

Topography: hummocky mountain slope

Physiognomy:

Veget. Stratum	Tree	Shrub	Herbaceous	Ground
Cover (%)	0	0	98	3
Height (cm)	-	-	8	0.5
Dominant spp.	-	-	*Carex nigricans*	*Polytrichum* spp.

Successional Status: static by snow presence, could succeed to Mountain Heather.

Biomass of Vegetation (Dry wt. in gm):

Forbs: trace

Graminoids: 94.3 (range = 93.9 to 94.7)

Mosses & Lichens: trace

Arboreal Lichens: none

Soil: Brunisolic with a parent material of residual shale.

Horizon	Depth (cm)	Roots	Texture	Consistency	Organic Matter	Colour
A	26	Abundant	Clay	V. Friable	V. high	Brownish
B	30	Abundant	Clay	V. Friable	V. high	Reddish
C	30+	Few	Course sand	Firm	Medium	Reddish-Brown

Animal Activity:

Caribou - 1 pellet group

Ground squirrels - a few burrows

Small rodents - 2 nests and some feces

Ptarmigan - pellets and sightings

Table 3. Canopy cover data, Stand #3 (Alpine and Forest Tundra Meadow)

Plant Species	Cover		Frequency (%)	Utilization	
	%	Class Number		Actual	Classification
FORBS					
Luetkea pectinata	2.00	4	30	0	none
Cassiope tetragona	1.49	4	16	0	none
Erigeron sp.	0.5	2	2	0	none
Antennaria lanata	0.38	2	16	0	none
Senecio triangularis	0.32	2	3	0	none
Claytonia lanceolata	0.05	1	10	0	none
Ranunculus eschscholtzii	<0.01	1	2	0	none
Anemone occidentalis	<0.01	1	2	0	none
Veronica alpina	0.05	1	12	0	none
Epilobium alpinum (mostly - some *Arctosstaphylos uva-ursi*)	0.10	1	20	0	none
Sibbaldia procumbens	<0.01	1	2	0	none
Phyllodoce sp.	0.01	1	4	0	none
GRAMINOIDS					
Carex nigricans	92.62	9	100	4 stems	light
Carex spectabilis	0.40	2	2	4 stems	light
Luzula spicata	0.26	2	10	1 leaf	light
Poa cusickii	0.02	1	6	0	none
MOSSES					
Polytrichum sp.	2.46	4	54	0	none
LICHENS					
Ground lichens (white)	0.04	1	2	0	none
Stereocaulon alpinum	0	1	0	0	none
Cladonia chlorophaea	0.04	1	6	0	none
Peltigera apthosa	0	1	0	0	none
Peltigera sp.*	0	1	0	0	none
Cetraria islandica	0	1	0	0	none

* orange edge

Community Type: Fellfield Tundra

Stand #4 Date: 10 August Elevation: 2355 m

Exposure: N Drainage: Good Slope: 2-5%

Topography: Hummocky mountain slope with some frost heaving

Physiognomy:

Veget. Stratum	Tree	Shrub	Herbaceous	Ground
Cover (%)	<1	2	20	3
Height (cm)	40	8	10-12	0.5
Dominant spp.	*Abies lasiocarpa*	*Salix nivalis, S. arctica*	*Dryas hookeriana*	*Rhacomitrium lanuginosum*

Successional Status: Climax

Biomass of Vegetation (Dry wt. in gm)

Forbs: 164.3 (Range - 54.8 to 244.6)

Graminoids: trace

Mosses and Lichens (mostly mosses 95%): 227.3 (range - 100.0 to 875.0)

Arboreal Lichens: none

Soil: Brunisolic with residual shale as parent material

Horizon	Depth (cm)	Roots	Texture	Consistency	Organic Matter	Colour
A	7	Few	Course sand	Loose	Low	Greyish
B	not present	-	-	-	-	-
C	7+	V. few	Course sand	Friable-firm	V. low	Brownish

Animal Activity:

Caribou - recent activity, 10 fresh & 25 old pellet group/0.4 ha, tracks, 1 antler.

Ptarmigan - pellets, sighting, nest

Coyote - 1 pellet

Ground squirrels - a few burrows

Table 4. Canopy cover data, Stand #4 (Fellfield Tundra)

Plant Species	Cover		Frequency (%)	Utilization	
	%	Class Number		Actual	Classification
TREES AND SHRUBS					
Salix nivalis/S. arctica	1.29	4	42	1 stem-old util.	light
Abies lasiocarpa	0	1	0	0	none
FORBS					
Dryas hookeriana	11.34	5	63	3 plants	light
Empetrum nigrum	1.15	4	4	1 plot	light
Cassiope tetragona	0.94	3	6	0	none
Arctostaphylos uva-ursi	0.80	3	2	0	none
Phyllodoce glanduliflora	0.50	2	1	0	none
Vaccinium vitis-idaea	0.36	2	55	0	none
Potentilla uniflora	0.20	1	9	0	light
Artemisia norvegica	0.15	1	9	0	none
Phyllodoce glanduliflora	0.50	2	1	0	none
Campanula lasiocarpa	0.07	1	24	0	none
Antennaria lanata	0.04	1	7	0	none
Polygonum viviparum	0.03	1	6	0	none
Silene acaulis	0.02	1	2	0	none
Pedicularis groenlandica	<.01	1	1	1 plant	moderate
Oxytropis podocarpa	<.01	1	4	0	none
Cerastium beeringianum	0	1	0	0	none
Sibbaldia procumbens	<.01	1	1	0	none
Veronica alpina	<.01	1	2	0	none
Sedum stenopetalum	0	1	0	0	none
GRAMINOIDS					
Poa cusickii	0.90	3	3	Possibly	light
Poa lettermanii	0.04	1	8	0	none
Luzula spicata	0.01	1	2	0	none
Hierochloe alpina	<.01	1	1	0	none
Carex nardina	0.13	1	20	1 leaf 1 plant	light
Carex albo-nigra	0.01	1	5	0	none
MOSSES					
Rhacomitrium lanuginosum	1.64	4	14	0	none
Aulacomnium sp.	0.46	2	44	Old Util. in 4 plots	light
LICHENS					
Cetraria aculata	0.19	1	74	0	
Thamnolia subliformis	0.12	1	50	0	
Stereocaulon alpinum	0.22	1	46	0	none
Usnea sp. (black)	0.21	1	30	1 sq cm	light
Cladonia chlorophaea	0.15	1	27	0	none
C. cenotea	0.04	1	17	0	none
C. cornuta	<0.01	1	4	0	none
Umbilicaria sp	0.02	1	10	0	none
Cetraria tilesii	0.03	1	12	0	none
Unidentified white ground lichens	0.11	1	13	0	none
Cetraria islandica	0.04	1	14	0	none
Peltigera apthosa	0.03	1	5	0	none
Dactylina arctica	0.04	1	14	0	none

Community Type: Alpine and Forest Tundra Meadow (Herb-Moss)

Stand #5 Date: 11 August Elevation: 2290 m

Exposure: NE Drainage: Good Slope: 2-5%

Topography: Mountain Slope

Physiognomy:

Veget. Stratum	Tree	Shrub	Herbaceous	Ground
Cover (%)	<1-2	8	70	14
Height (cm)	100-600	15	30-40	0.5
Dominant spp.	*Picea engelmannii*	*Salix barratiana*	*Artemesia norvegica*, *Valeriana sitchensis*, *Anemone occidentalis*, *Cassiope tetragona*, *Vaccinium scoparium*	*Aulacomnium* sp.

Successional Status: Successional to climax *Picea engelmannii* or *Abies lasiocarpa* with understory of heather. Maintained by water runoff from snow beds above. Very lush with a great number of species.

Biomass of Vegetation (Dry wt. in gm):

Forbs: 107.2 (range = 760 to 159.0)

Graminoids: 77.0 (range = Present - 178.6)

Mosses and Lichens: (no lichens) 8.8 (range = 0-21.2)

Arboreal Lichens: 0

Soil: Brunisolic with a parent material of residual shale/dolomite.

Horizon	Depth (cm)	Roots	Texture	Consistency	Organic Matter	Colour
A	72	Abundant gradually decreasing with depth	Silt	V. friable	High, decreasing with depth	Brownish

Animal Activity:

Caribou - sightings and pellets

Moose - sightings and pellets

Mule deer - sightings and pellets

Black bear - scat

Ground squirrels - burrows (many)

Soil: Brunisolic with a parent material of residual shale/dolomite

Horizon	Depth (cm)	Roots	Texture	Consistency	Organic Matter	Colour
A	4	Abundant	Clay	V. friable	V. high	Greyish
B.	14	Few	Clay	Friable	High	Brown-Reddish
C.	14+	V. few	Fine sand	Firm	High	Brownish

Animal Activity:

Caribou - pellets (5 fresh and 4 old in 0.4 ha plot).

Moose - sighting, pellets (3 fresh and 4 old in 0.4 ha plot).

Elk - no pellets observed.

Deer - signtings, pellets (2 fresh in 0.4 ha plot).

Ground squirrels - burrows (few).

Table 6. Plant canopy cover data, Stand #6 (Engelmann Spruce-Subalpine Fir).

Plant Species	Cover		Frequency (%)	Utilization	
	%	Class Number		Actual	Classification
TREES AND SHRUBS					
Abies lasiocarpa	42.88	7	64.0	0	none
Picea engelmannii	23.45	6	35.0	0	none
Pinus contorta	0.67	3	1.0	0	none
Salix barrattiana	0.04	1	5.0	0	none
S. arctica	0	1	0	0	none
Juniperus communis	0	1	0	0	none
FORBS					
Cassiope tetragona	21.58	6	65.0	1 stem	light
Vaccinium scoparium	16.27	6	97.5	1 stem heavy util. 1 plot	moderate
Phyllodoce empetriformis	11.15	5	65.0	0	none
P. glanduliflora	2.00	4	5.0	0	none
Artemisia norvegica	1.00	3	2.5	0	none
Empetrum nigrum	0.46	2	7.5	0	none
Luetkea pectinata	0.32	2	5.0	0	none
Lycopodium sp. (small)	0.25	1	5.0	0	none
Antennaria lanata	0.02	1	2.5	0	none
Erigeron sp.	0.01	1	2.5	0	none
Veronica alpina	0	1	0	0	none
Epilobium alpinum	0	1	0	0	none
Senecio triangularis	0	1	0	0	none
Pedicularis groenlandica	0	1	0	0	none
Pyrola secunda	0.09	1	12.5	0	none
Arnica diversifolia	0	1	0	0	none
Erigeron sp.	0	1	0	0	none
Erigeron perigrinus	0	1	0	0	none
Polygonum viviparum	0	1	0	0	none
Parnassia fimbriata	0	1	0	0	none
Anemone multifida	0	1	0	0	none
A. occidentalis	0	1	0	0	none
Sibbaldia procumbens	0	1	0	0	none
Potentilla diversifolia	0	1	0	0	none
Valeriana sp.	0	1	0	0	none
GRAMINOIDS					
Carex albo-nigra	0.5	2	2.5	0	none
C. nigricans	0	1	0	0	none
Poa arctica	0	1	0	0	none
P. cusickii	0	1	0	0	none
Luzula spicata	0	1	0	0	none
MOSSES					
Dicranum scoparium	22.58	6	57.5	0	none
Barbilophozia hatcheri	19.02	6	50.0	0	none
Polytrichum sp.	0.07	1	7.5	0	none
LICHENS					
Peltigera apthosa	1.05	4	7.5	0	none
Stereocaulon alpinum	0.05	1	2.5	0	none
Cetraria islandica	0.24	1	22.5	0	none
Thamnolia subuliformis	0.04	1	10.0	0	none
Cladonia rangiferina	0.01	1	2.5	0	none
C. chlorophaea	0.02	1	10.0	0	none
C. spp. (including *C. cenotea*)	0.19	1	27.5	0	none
Letharia vulpina	< .01	1	2.5	0	none
Alectoria lanestris	< .01	1	2.5	0	none

Table 7. Additional plant species observed in the upper Evelyn Creek area.

GRAMINOIDS

Agropyron latiglume
Calamagrostes purpurescens
Poa arctica (= Poa grayma)

FORBS

Agoseris aurantica
Anemone drummondii
Arabis cf. *lyalli*
Arnica rydbergii
Crepis nana
Draba cf. *oligosperma*
Epilobium angustifolium
Erigeron pallens
Heracium gracile
Papaver kluanensis
Petasites frigidis
Saussurea densa
Saxifraga caespitosa
Senecio fremontii
Stellaria longipes
Taraxacum cf. *lyratum*

MOSSES, CLUB-MOSSES & LICHENS

Cladina arbuscula
Cladonia chlorophaea
Cladonia deformis
Cladonia fimbriata
Cladonia gracilis
Cladonia multiformis
Dicranum sp.
Hylocomium sp.
Lecidea granulosa
Lophozia sp.
Lycopodium selage
Nephroma expallidum
Solorina crocea